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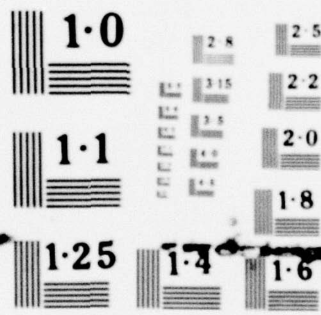
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6 THE EFFECT OF AIR TRAFFIC CONTROL
EXPERIENCE LEVELS ON
QUALITY OF SERVICE.

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14 AFIT-LSSR 26-79B

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The median experience level of Air Force air traffic controllers has decreased significantly over the past five years. The purpose of this thesis is to determine what impact, if any, this high turnover rate has had on the quality of ATC services provided as measured by Hazardous Air Traffic Reports (HATR). Trend analysis, proportions, multiple linear regression, and tests on the differences of the population means were used in the analysis of the total, facility, and local experience levels of the controllers cited as cause of the HATRs. The impact of weather, traffic volume, equipment failure, the presence of a crew chief, and the presence/absence of a trainee were also examined. The data base consisted of all HATRs filed from January 1975 to April 1978. The findings were: (1) that the number of HATRs received by controllers is decreasing, (2) the mean experience levels of controllers is not changing significantly and (3) that a controller is most vulnerable to receive a HATR in his first two years or less on station, regardless of his previous facility and total experience.

LSSR 26-79B

THE EFFECT OF AIR TRAFFIC CONTROL EXPERIENCE LEVELS ON QUALITY OF SERVICE

A Thesis

Presented to the Faculty of the School of Systems and Logistics

of the Air Force Institute of Technology

Air University

In Partial Fulfillment of the Requirements for the

Degree of Master of Science in Logistics Management

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has been accepted by the undersigned on behalf of the faculty of the School of Systems and Logistics in partial fulfillment of the requirements for the dgree of

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(CONTRACTING AND ACQUISITION MANAGEMENT MAJOR)

DATE: 7 September 1979

Todd S. Stewart
COMMITTEE CHAIRMAN

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CHAPTER I

BACKGROUND

Overview

The attrition rate within the air traffic control career field [Air Force Specialty Code (AFSC) 272XO] has caused a virtual turnover in personnel over the last five years (15). During this same time period, the total Air Force flying hours has decreased while the cost of man-power and equipment has increased tremendously as can be seen from recent USAF budgets. Historically, the use of financial incentives in the air traffic control career field has improved the retention rate, but recently the instability of the Selective Re-Enlistment Bonus (SRB) incentives has actually contributed to manning turbulences (see Table 1). The impact of the above factors is unknown. A study was needed to ascertain the effect of controller attrition on the quality of United States Air Force (USAF) air traffic control services.

Intuitively, it seemed that as the experience level in the controller force decreased, the quality of the services provided would decrease as well. However, this judgment did not appear to be founded in empirical evidence (9). We believed that management needed to know

TABLE 1*

AIR TRAFFIC CONTROL CAREER FIELD RETENTION RATES

	AFSC			A.F.		
YEAR	1st TERM	2nd TERM	CAREER	1st TERM	2nd TERM	CAREER
72	64.3%[a]	----[b]	93.2%	32.6%	78.8%	94.4%
73	45.8[c]	73.9%[d]	97.1	20.4	72.5	----
74	19.3[e]	64.8[f]	94.2	31.1	73.4	96.9
75	57.0[g]	56.4	92.1	40.1	75.4	97.2
76	45.3[h]	37.1	88.0	37.5	67.8	91.8
77t[i]	47.0	50.7	95.5	33.1	73.9	94.7
78[j]	46.6	57.5	90.8	41.1	64.7	92.6

*This table depicts the rention rates as a percentage with appropriate SRBs.

NOTE: *a*-VRB 4; *b*-Pro Pay $75; *c*-VRB 2; *d*-Pro Pay $50; *e*-No VRB; *f*-Pro Pay $25; *g*-SRB 3; *h*-SRB-2 *i*-Zone A SRB 3, SRB 1 second term; *j*-Zone A SRB 4, SRB 3 second term.

whether or not the high attrition rates and the lower resultant experience levels were, in fact, posing a problem before they considered any actions to halt the exodus. Therefore, the purpose of this research was to determine whether or not the number of Hazardous Air Traffic Reports (HATRs) submitted on USAF air traffic controllers was related to the high attrition rate. The HATR was a valid measurement because it was specifically designed to report hazards within the Air Traffic Control (ATC) environment. However, it remained to be seen if the HATR had a reliability commensurate with its validity. If a significant correlation existed between USAF air traffic controller experience levels and the volume of reported HATRs, then management would not only be able to empirically determine whether or not they had a problem, but also gain an effective management tool for evaluating the air traffic control force (9).

This study is necessary for many reasons. The first is safety. Today a controller handles much faster aircraft than did his predecessors. The aircraft are larger and much more expensive. Further, the policy of the United States Air Force is to make maximum use of Instrument Flight Rules wherever possible. These factors not only increase the number of aircraft handled by air traffic control, but they also decrease the time factor in which a controller can make a decision. This results in a

stress situation which can lead to false conclusions and errors. Little is currently known concerning the relationship between a controller's experience level and his ability to react effectively in stress situations (4; 8; 9; 13; 18).

Further, Air Force Communications Service (AFCS) air traffic controllers not only provide the USAF with peacetime services, but they form the core from which air traffic control operations can be expanded in time of war. A seasoned force is essential to support air operations if the Air Force is to maintain a worldwide capability, as we cannot depend solely on indigenous support overseas. Again, the impact of a reduced experience level across the air traffic control force on this required capability is not known.

Another reason for this study is effective resource management. Generally speaking, a junior force contains lower ranking airmen who are paid less than the more senior airmen who would make up a more experienced force. The economics of the situation is that the payroll costs of a younger force, as compared to a more senior force, could be significantly lower, provided the younger, less experienced force would produce service of an acceptable quality. However, training and other turnover costs would increase (turnover cost = training, recruitment, in-processing, etc.). This fact is

accentuated when one considers that there are roughly 5,800 personnel assigned to the 272XO career field (see Appendix D).

The question of where the Air Force would obtain the core of experienced managers upon which to expand the force if necessary is left to another study.

Problem Statement

Having identified the potential area of concern, a more specific statement of the research problem can be offered. Specifically, the median experience level of skilled USAF air traffic controllers has declined by more than 20 percent during the last three years (see Table 2). The impact of the reduced experience level on the USAF's ability to provide adequate air traffic control services is not known. In particular, responsible managers do not know if a significant relationship exists between the experience level of USAF air traffic controllers and the rate of reported air traffic hazards.

Scope

In limiting the problem, we had certain boundaries, assumptions, and research objectives. Our data base contained all HATRs involving Air Force controllers during the period of June 1975 to April 1978. This constituted a census of information compiled by AFCS on all filed Air Traffic hazards for the period. The

TABLE 2

AFCS 272XO PERSONNEL MEDIAN EXPERIENCE LEVEL

Year	All 272XO	Skilled AFSCs (5,7,9 levels)
Jan 1975	4.8	6.2
Jan 1976	3.49	5.2
Jan 1977	3.1	4.7
Jan 1978*	3.3	4.9

*First two quarters only.

SOURCE: HQ MAC/DPAFR.

identified controllers were divided into two categories, cause and noncause factors. The judgment as to which controller received the cause designation where more than one controller was identified was based on the analysis contained in the HATR narrative.

We limited the analysis to USAF active duty controllers, omitting reserve, foreign military, and any civil controllers that were stationed at active Air Force facilities because they were not considered in experience level computations. Supervisory reports such as Facility Management directives and command directives were also deleted to enable us to look only at the experience level in the 272XO career field.

In formulating the research objectives, certain assumptions were made to further bound the analysis. There are many factors, natural and otherwise, affecting a complex situation such as the interaction between an air traffic controller and a pilot. Geography and aircraft type, as well as type of mission, while possibly contributing to certain HATRs, were not considered due to the diversity of factors in each area.

Research Objectives

This research had three major research objectives.

Objective 1. To identify trends in the data that may reflect the character and changes in the character of the controllers and situational factors reported during the January 1975 through April 1978 time frame. Specifically:

1. Trends in the total experience.

2. Trends in the experience levels of the controllers in facilities of the same type as that in which the HATR occurred.

3. Trends in the experience levels of the controllers in the specific facility involved.

4. To identify patterns in the situational variables (i.e., traffic and weather conditions, etc.).

Objective 2. To determine if a statistically significant relationship existed between the number of reported hazards and the following:

1. Total experience (XT).
2. Experience in same type facility (XF).
3. Experience at the local facility (XL).
4. Situational variables (i.e., weather, traffic density, crew chief, equipment failure, and trainee).

Multiple Linear Regression was used to performed this analysis. The operational definitions, models, and model amplifications are deferred to Chapter III (Methodology).

Objective 3. To determine if there were any statistically significant differences between the experience levels and situational factors identified in the HATRs where the controller was cited as cause, and those HATRs attributed to other factors (i.e., pilot, material, etc.).

In conclusion, by showing a trend in the three levels of experience involving air traffic controllers, regressing these levels on the HATRs over the same time period, and analyzing the effects of environmental or external factors bearing on the incident resulting in a HATR, we were able to show whether or not a correlation existed between experience levels of USAF air traffic

controllers and aircraft hazards as reported in the Hazardous Air Traffic Reports.

Plan of the Report

The remainder of this thesis is concerned with the delineation and analysis of the aforementioned problem. The following chapter is concerned with our background investigation into the problem, and related studies and investigations, both past and present. Chapter III contains our data selection and analysis plan, the methodology for examining the data, and the hypotheses in support of our objectives. Chapter IV summarizes the results of our investigation, and the fifth and final chapter contains our conclusions and recommendations.

CHAPTER II

LITERATURE REVIEW

In the first chapter, we introduced the general purpose of the research and provided the scope, assumptions, and limitations of this study. This chapter presents an overview of current related knowledge, a description of the data source, and some cautions that must be observed when considering the subjects of Air Traffic Control, HATRs, and the environment of the air traffic controller.

Previous Studies

Previous studies of the air traffic controller are limited. Two Federal Aviation Administration (FAA) studies performed by Cobb (1) and Hauty and Trites (3) addressed experience but these studies were limited in scope and depth.

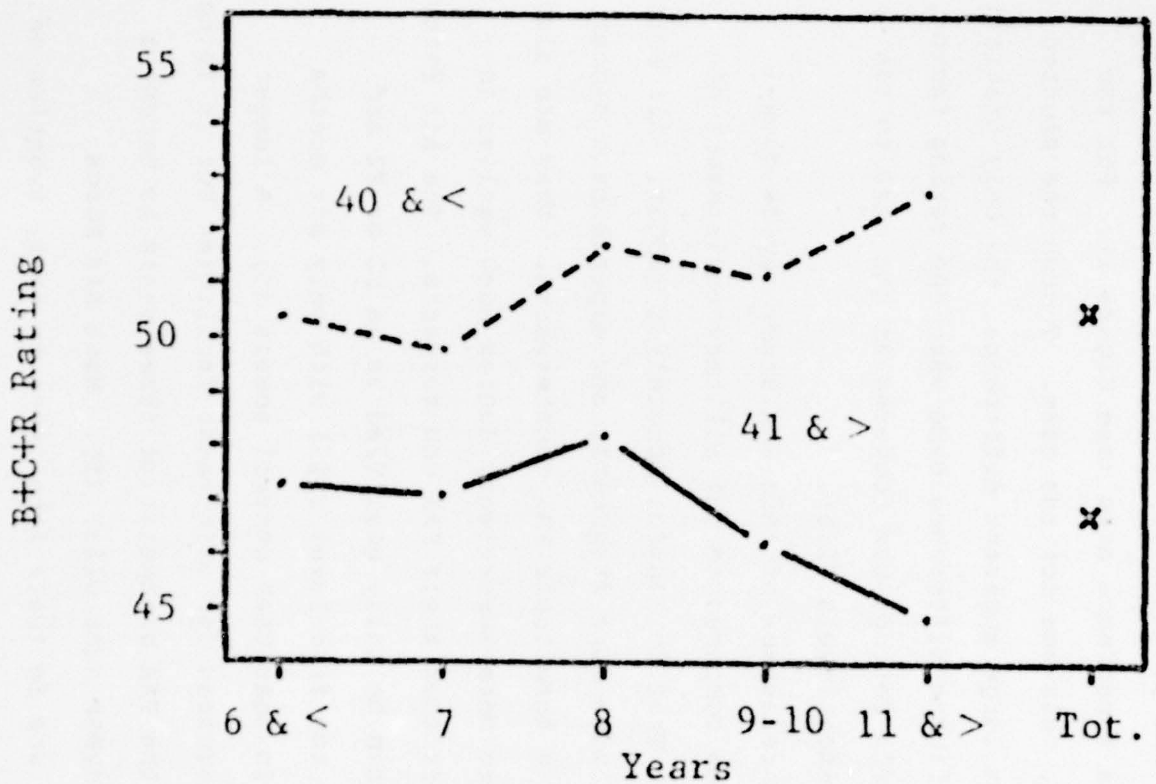
The Cobb study, "Relationships Between Chronological Age, Length of Experience, and Job Performance Ratings of Air Route Traffic Control Specialists," was primarily concerned with performance, reactions to stress, and any association there might be between these factors and the age and experience level of the controller. A multipart survey of both peer group and supervisors

established three rating factors and combinations thereof: peer evaluation on the radar control position (R), supervisor general evaluation (B), supervisor technical evaluation (C), and a combination of both supervisor ratings and all three ratings combined, resulting in five standardized rating factors with a mean of 50 (1:5). The survey covered 568 controllers from age 26 to 51 at four air route traffic control centers located in the eastern United States. It indicated that there was a low but statistically significant negative relationship between age and performance ratings (1:5). When the analysis was done between experience as a controller and performance there was also a negative relationship but it was not statistically significant (1:5). The survey covered all the controllers at three positions of operation: interphone/ radio, coordinator, and radar controller. The radar position was the only position where significant differences were found between controller groups of different lengths of ATC experience (1:7).

When age and experience were considered together, difficulties resulting from the frequency distribution of age and experience imposed limitations that prevented the running of analysis of variance (ANOVA) or other more sophisticated analysis (1:7). When the mean composite ratings were plotted, using dichotomized groupings based

on age, it was noted that for the age group of 40 or less, the mean performance rating using three of the five factors, B, C, and R, generally increased in the eight to eleven years experience area (see Figure 1). [illegible] the older group, this was not the case. Though the plotted data shows a large apparent difference, the only statistically significant difference came when one rating factor, a supervisor's rating, was compared at the nine to ten year experience levels (1:8).

The relevance of this FAA study may be questionable when compared to the military environment of the USAF Air Traffic Control Specialist (ATCS). Air Force controllers move more frequently and experience a higher turnover rate than their FAA counterparts. They are also promoted into more supervisory duties much earlier in their careers than their FAA counterparts. The Air Force controller can be fully qualified as an E1 or E2 and upgraded to the five-level skill with only six months experience in most USAF control towers (5). A longer period is required for most radar facilities but it is no where near the FAA parameter of three years to become a GS-12 journeyman controller (5). Most Air Force controllers are in their late teens or early twenties on entry and reach the apparent critical age of forty much later in their twenty to thirty year career (9; 14).



SOURCE: 1; Cobb

Fig. 1. Means of Ratings for Older vs. Younger Controllers of Different Experience Groups

Though the Cobb study indicated that controllers with more than eleven years experience received consistently lower ratings in the radar control position than the less experienced controller, this fact is not easily generalized in the USAF environment. At the eleven to twelve year point, the Air Force controller is normally used as a supervisor and, as such, is not expected to perform primarily as a controller, but as a supervisor or coordinator (9,14).

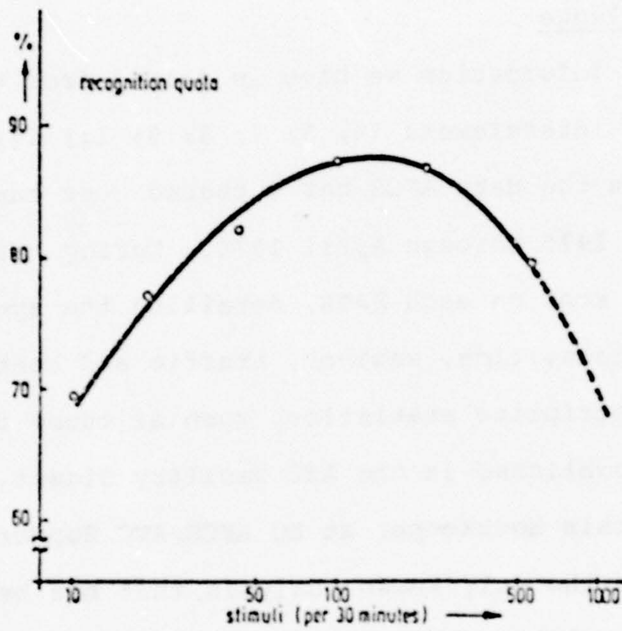
In the Hauty and Trites study, "Biomedical Survey of ATC Facilities on Experience and Age," it was revealed that a stronger relationship existed between experience and complaints of mental and physical stress than between age and complaints of mental and physical stress (3:4,5). Again the difference in environments makes generalization from the FAA to the USAF situations difficult.

In a paper delivered before a meeting of the NATO Advisory Group for Aerospace Research and Development, Dr. Hans J. Zetzmann considered workload and performance limiting factors of air traffic control radar operators. The focus of the paper was on workload and performance factors as they related to recognition of situations and reaction to visual stimulation in the radar control environment. A critical and somewhat "intuitive" (4; 5; 8; 9) belief that is supported by Dr. Zetzmann is that the critical time for errors in the air traffic control

system is when there is a lack of, not an overabundance of, traffic to be handled. As indicated in Figure 2, a low stimulation rate yielded a much poorer recognition factor than a high stimulation rate. Mistakes made at the higher stimulation rate can be traced back to fatigue or excessive complexities (18:9-1).

Mr. V. D. Hopkin of the RAF Institute of Aviation Medicine, Farnborough, England, presented a paper, "Work-Rest Cycles in Air Traffic Control Tasks," at the same NATO meeting. He pointed out that effects of shift work over a period of time is not known, and that the effects of age (which comes along with experience) may make it more difficult to adapt to changing work/rest cycles (6:10-6). This may be relevant to the USAF environment in that rotating shifts are the normal means of operating a facility eighteen to twenty-four hours a day. Mr. Hopkin further related, in remarks to the meeting, that in the U.S. and England, younger personnel, without previous aircrew experience were recruited and were just as proficient and sometimes better than, older men who have taken up the job after having aircrew experience (6:10-9). The young airmen who make up the greatest part of the USAF ATC personnel come on board with no prior experience (9,15).

Mr. Hopkin indicated that prior to 1970, very limited literature was available concerning the measurement of the effects of age, experience, and shift work on



Relationship between stimulation rate and recognition quota

SOURCE: 18; Zetzmann.

Fig. 2. Relationship Between Stimulation Rate and Recognition

the performance of an air traffic controller (6:10-4). The time horizon of that remark has been extended significantly. It's now 1979 and neither the FAA nor HQ AFCS know of any existing definitive studies (2; 4; 5; 8; 9; 11:14-17).

Current Knowledge

What information we have is gained from the experience of our interviewees (4; 5; 7; 8; 9; 11; 14; 15; 16; 17), and from the data AFCS has gathered over the period from January 1975 through April 1978. During this time, records were kept on each HATR, detailing the specific situation, place, time, weather, traffic and controller factors. Descriptive statistics, such as those found in Appendix A, published in the ATC Facility Digest, May/June 1977, by Captain Houtkooper at HQ AFCS/ATC Support Division, are the only known analysis that has been done with the data (13). While the descriptive statistics are revealing as to who is commiting errors, it does not reveal significant relationships or causal factors.

Intuitively, experience and quality of service are related. In telephone interviews this hypothesis has been supported by many personnel in positions of authority and experience (4; 5; 7; 8; 9; 11; 13; 14; 15; 16; 17). Though the hypothesis is attractive, intuitively, little empirical evidence exists to support it. In fact,

evidence in the form of the Cobb study for the FAA indicates that performance may be inversely related to age and experience (1:5). In the opinion of Dr. Mary Lewis of the Psychological Branch at the FAA Aeromedical Institute this is a supportable hypothesis (8).

From the investigation and telephone interviews with Air Force ATC managers it is evident that little is known about the relationships between experience level and job performance. In the telephone interviews (4; 5; 7; 9; 11; 13; 14; 15; 16; 17) the following question was posed: "What is the effect of the declining ATC experience level on the performance of the AFCS mission." The answers were all of the same nature, ". . . We don't know, but it cannot be good [4; 5; 7; 9; 11; 13; 14; 15; 16; 17]." When the question was posed to FAA personnel the answer was essentially the same. Dr. Lewis stressed the difficulty of measuring performance and of identifying performance factors. The FAA is better able to do some research on working controllers in the Air Route Traffic Control centers because the large ratio of supervisors to controllers permits multiple, independent ratings. In terminal facilities, the smaller number of controllers and supervisors makes it difficult to measure performance (8). The Air Force is in the same situation of having a limited number of qualified observers to measure an individual's performance, independent of other factors (9).

Three factors, the HATR, the Chief, Air Traffic Control Operations (CATCO), and the training load are central to the theme of this paper. (1) The occurrence of the HATR is not taken lightly, and some HATRs are accidents that just didn't happen. (2) The way the CATCO does his job is reflected in the rate of complaints and HATRS. (3) The training load absorbed by the controller is extremely heavy. Each of these subjects needs to be considered at length before developing the specific tests for the analysis of the data.

The HATR, A Rare Event

The filing of a HATR is a fairly rare event (8). With an average of 5,844 controllers assigned in 1978, there were forty-five HATRs attributed to USAF controllers. This yields an annual average of .0077 per controller. This compares with thirty-seven HATRs and an annual average of 5,871 controllers or .0063 per controller in 1977 (8).

Prior to 1975 the reporting of Air Traffic hazards was limited to the Hazard Report, AF Form 457 (see Appendix F). This system was somewhat difficult for the pilot and controller in that it required extensive time and effort to complete the paperwork (17). Thus, the form was often ignored.

The HATR (Appendix C), on the other hand, was specifically designed to report hazards encountered within the ATC system, and is easier and more readily completed. This easier reporting may explain the apparent increase in the number of hazards reported from 81 and 75 in 1974 and 1975 respectively to 365, 442, and 428 in the years 1976 through 1978 (Appendix A). For the years 1975 through 1978, seventy-five valid HATRs (ATC cause factor) were filed against USAF controllers in 1975, sixty-two in 1976, thirty-seven in 1977, and forty-five in 1978.

The number of HATRs may well be affected by the effectiveness of managers within the ATC system. The primary figure is the CATCO.

The CATCO's Role

The Chief of Air Traffic Control Operations, or CATCO, is a critical link in the reporting of HATRs. As the responsible figure for all ATC management at the operating location, this individual, more than any other, may affect the HATR rate. Whether responsible for a single control tower at a remote support base or a multi-facility operation with Tower, Radar Approach Control and Precision Approach Radar, the CATCO is the central figure. Aside from personnel management functions, the CATCO is a public relations representative for his people. Close contact must be maintained with the flying customers.

Coordination must be closely maintained with adjacent facilities and, most of all, the questions, gripes, and complaints of controllers and pilots alike must be answered. In the process of answering these complaints it is felt that many potential HATRs are short stopped (7; 9; 11; 13; 14; 15; 17). By doing their jobs well, the CATCOs are taking complaints, identifying problems, and taking corrective actions thereby alleviating the cause of many potential HATRs before any formal reporting is initiated.

The Training Load

One additional factor must be considered before developing the specific methodology for the analysis of the data: The training load. Within ATC, both military and civilian training is an ongoing process. New controllers train for initial qualification, transferred controllers train for facility qualifications (rating), and all controllers must have proficiency training. Any time an unqualified controller occupies a control position, that controller is under the direct supervision of a certified controller. This is a one-on-one situation and may not be violated (AFCSR 60-5).

The supervising controller is in a difficult position. He must allow the trainee to work, just as an instructor pilot must allow the student pilot to fly the airplane. The difficulty is, how far can one let a

trainee go before assuming direct control? The student must be allowed to make mistakes in order to learn, but where does one stop? Sometimes, the student gets too far along before the instructor intervenes. In flying, the ramifications of this are clearly evident. In ATC, it may not always result in an accident/incident, but it may be a significant cause in the number of HATRs because, in performing instructor duties, the supervisor may loose proficiency and be unable to salvage a situation brought on by the student before it becomes a HATR.

The declining experience level in the USAF ATC system is emphasized and partially explained in the training situations facing the Air Force (15). As evidenced in the following analysis of manning documents and projected loss/gains (Appendixes F and G), if there is a significant relationship between controller training, the declining experience rate, and the quality of services, it may well lie in the area of monitoring trainees and the very high training load handled by USAF facilities (4; 9; 15). The FAA training load is somewhat lighter than that of the Air Force (5; 8). This is due to the rapid turnover in Air Force controllers and the resulting heavy training level required to meet Air Force needs, as evidenced by the USAF Airman Manning Ledger (Part 11, Appendix D), that indicates that, as of 31 July 1978, the E3 five-level positions were 833 percent manned, and the

E5 five-level authorizations were at 42 percent. This relationship holds at the seven-level skill as follows: E5 seven-levels, 549 percent manned while E6 seven-levels were manned at 62 percent. The indications are clear. The bulk of the front line controllers for the Air Force are E3 five-levels who, by rank and skill, are certainly first term airmen. Also, many first line supervisors positions are being filled by E5 seven-levels who would be primarily second term airmen.

The future is not bright in the training area. As Appendix D indicates, the projected unskilled three level entries for third quarter 79 are 165 percent of authorized with over 30 percent of the inputs at the grade E4 and above. The cross training of E5, E6, and E7, personnel into the 272X0 career field who have very little ATC experience may be having the effect of also reducing the overall experience levels as they fill supervisory positions and could be managing a facility within one year of cross training. Further dilution of the experience levels will occur as first term airmen are replaced by new enlistees and the core of senior airmen, E6-E9, continues to complete their careers and retire. The loss rate of senior airmen, as indicated in Appendix E, supports this analysis.

CHAPTER III

METHODOLOGY

Having reviewed the problem, research objectives, background of the subject, and related studies, we introduce the data base and methodology. This chapter covers the data base and the statistical techniques used in the analysis of the various experience levels. Multiple linear regression, and descriptive and inferential statistics were used to determine whether or not there was any statistically significant relationship between levels of experience and HATRs. The analysis was performed through the use of regression, trend analysis, descriptive characteristics of the data, porportionment of the data, and the use of the Student's t-test for significant differences.

The data file for this analysis consists of all the HATRs filed from 1 January 1975 through 30 April 1978. The population is all USAF ATC controllers listed on the HATRs, regardless of cause factor (the universe is all USAF air traffic controllers). The file was made available through Colonel Derrell L. Dempsy, Director of TRACALS Management, DCS/Air Traffic Services, HQ AFCS, with coordination through Lieutenant Colonel David J.

Martinson, Branch Chief, Air Traffic Control Support Branch, DCS/Air Traffic Services, HQ AFCS, Scott Air Force Base, Illinois.

Each HATR record consisted of the location, time, situation (near midair/nonnear midair), and other factors describing weather, supervisory factors, traffic conditions, equipment status, and cause factors. Further, each record contained specific information, as to the experience levels (total ATC, same type facility, and local) of controllers involved (See Appendix G). A narrative description of events was included as a part of the file making it possible to identify specific controllers when information on multiple controllers was listed. Cause was assigned on the basis of this narrative description and designation of the controller/position of operation as detailed in the narrative.

The following factors were deemed relevant to this research and were extracted from the HATR data bank to construct a file for analysis. Each factor is identified and a statement made as to its operational definition and use in the analysis.

HATR. Hazardous Air Traffic Report. A report filed by pilots, controllers, or other competent authority when hazards relating to the flying and air traffic environments are identified. This is nominal level data

that may be treated as ratio data when grouped over specific intervals of time.

Total Experience. The length of time, in calendar months, that the individual controller has been assigned Air Traffic Control duties including work at all facilities. This is ratio level data.

Facility Experience. The length of time, in months that the individual controller has been assigned ATC duties in a facility of the same type, e.g., control tower. This is a ratio level factor.

Local Experience. The length of time in months that the individual controller has been assigned ATC duties in the specific facility prior to the occurrence of the HATR. This is a ratio level factor.

Weather. The weather conditions, stated as Visual Meteorological Conditions (VMC) or Instrument Meteorological Conditions (IMC), that existed at the time of the HATR. This variable has been transformed from four factors including day/night to a dichotomized factor, VMC/IMC without regard to time. This is a nominal level factor treated as a zero-one variable with one indicating the presence of VMC and zero indicating IMC conditions.

Traffic. The level of air traffic activity that existed at the time of the HATR. This factor has been transformed from the three measures, light, moderate, and heavy, to light, and moderate to heavy. This was done a priori based on the Zetzmann paper as outlined in Chapter II of this study. The factor is nominal and defined as follows: zero (0) indicates moderate/heavy and one (1) indicates light/not reported.

Crew Chief. An individual, fully qualified in all positions within a facility, assigned duties as a supervisor, not having to occupy a specific control position. A nominal variable coded one indicates the presence, and zero indicates the absence of an assigned crew chief.

Equipment Status. If the malfunctioning or absence of ATC or air navigation equipment was a factor in the HATR, the condition was identified by a zero-one variable; zero (0) for no failure, one (1) indicating a failure.

Monitoring a Trainee. The task of observing, correcting, and taking responsibility for the actions of an unqualified individual performing ATC duties. The presence of a trainee is indicated by one (1) of the zero-one variable, and zero (0) indicates no trainee.

Emergency. If an emergency condition existed as declared by the pilot or other competent authority, its presence was indicated by the one (1) of the zero-one variable.

The aforementioned variables fall into two categories, those impacting on the controller and those impacting on the situation (see Figure 3). The factors relating to the controller and the situation were all available in the data bank and were used to construct the specific tests as outlined in our objectives.

The data file consisted of all HATRs filed during the period June 75 through April 78. Of these, 178 involved controllers as cause factors, identifying 203 controllers. Further, 279 other controllers were identified but were not cause factors. This yielded a total population of 482 controllers for analysis. Twenty-five other HATRs were identified as controller caused but no controller experience levels were available in the data.

Trend Analysis

Trend analysis was useful in setting the stage for the inferential studies that followed. As the major concern of this thesis was the declining experience level and the effect that it may have had on the quality of service as measured by the HATR rate, the analysis involved plotting the various experience levels (total, facility, and

CODE: - - - = our postulate or belief of a relationship.

—— = our postulate supported by previous studies.

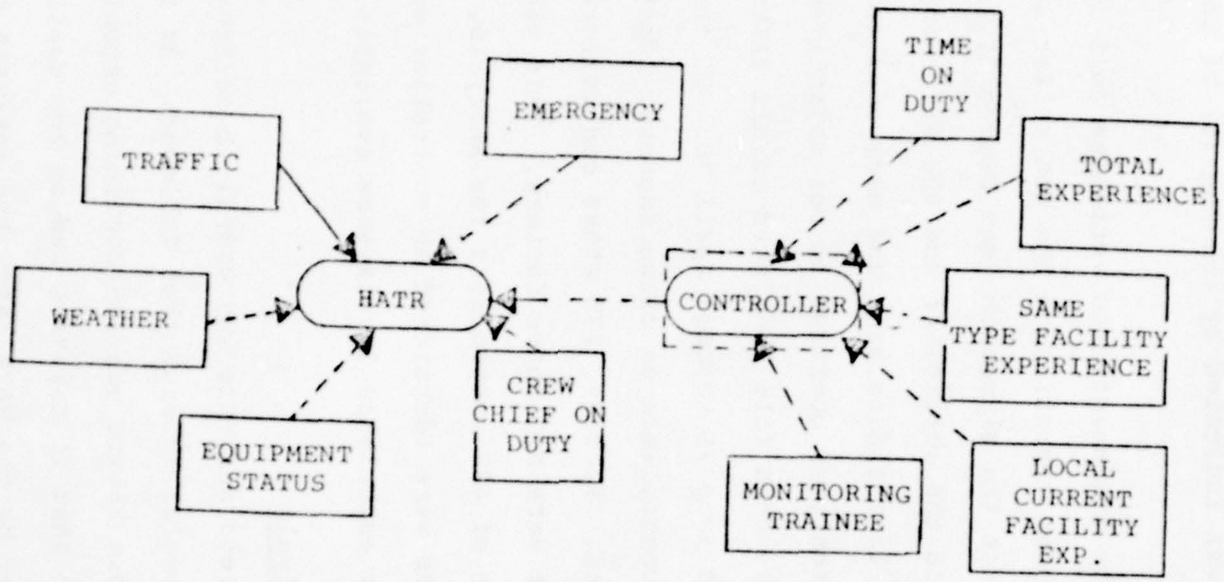


Fig. 3. Relationship of Variables

local) against the HATRs over time. A line of best fit was computed by the least squares method and revealed trend information in support of objective number one.

Further descriptive techniques were employed to compare the various experience levels and the proportions of experiences between the groups. A test of the slope of the lines of best fit was of the form:

$$\beta = \hat{\beta} \pm Z_{.10} * \frac{s}{\sqrt{\Sigma x_i^2}}$$

where:

β is the true slope,

$\hat{\beta}$ is the computed value of the slope from the sample,

Z is the Z value for a 90 percent CI,

s is the square root of the residual variance, and

Σx_i^2 is the sum of $(X-\bar{X})^2$ from the sample.

with

$$H_0: \beta = 0$$

$$H_1: \beta \neq 0$$

The test of proportion was:

$$P_1 - P_2 \pm Z_{.10}\sqrt{\frac{P_1(1-P_2)}{n_1} + \frac{P_2(1-P_2)}{n_2}}$$

where:

P_i is the population of the sample,

$(1-P_i)$ is the proportion not in the sample, and

n is the sample size.

with the Hypothesis:

$$H_0: \; P_1 = P_2$$

$$H_1: \; P_1 \neq P_2$$

A review was made of the categorical variables to attempt to identify any significant patterns that may have existed.

Multiple Linear Regression

Multiple linear regression allows the researcher to study the linear relationship between a set of independent variables and a dependent variable while taking into account the interrelationships among the independent variables. The basic goal is to identify a linear combination of independent variables which explains, to as high a degree as possible, the action of the dependent variable. The linear combination can then be used to predict values

of the dependent variable, and the contribution of each individual regressor in the prediction can be assessed.

The use of the multiple regression step-wise procedure was intended to test the effects of our ratio and nominal level independent variables, i.e., experience levels, weather, etc., in order of their explanatory power, on the dependent variable. The model for the regression was:

$$Y_i = B_0 + B_1X_1 = B_2X_2 + B_3X_3 + \ldots + B_8X_8 + e_i$$

where Y_i = dependent variable . . . HATRs involving USAF air traffic controllers from January 1975 to April 1978.

B_0 = a constant developed through the regression.

B_i = the individual coefficients of each regressor, their total being equal to the slope of the line (10:4-45).

X_1 = the measure of the mean total experience levels of the controllers involved in reported HATRs.

X_2 = the mean of the experience levels of the controllers in the same type of facility.

X_3 = the mean of the experience levels of the controller in the local facilities upon which a HATR was filed.

X_4 = the presence or absence of a crew chief.

X_5 = weather conditions, IFR/VFR.

X_6 = traffic conditions, moderate to heavy, or light.

X_7 = controller training in progress.

X_8 = equipment status at the time of the occurrence.

e_i = the residuals or unexplained variation.

An F-test was employed to test the overall significance of the model. The hypothesis for this test was:

$$H_0 : B_1 = B_2 = B_3 = \ldots = B_8$$

$$H_1 : B_1 \neq B_2 \neq B_3 \neq \ldots \neq B_8$$

Should H_0 be rejected, the Student's t-test would be employed to test the significance of the individual regressors. The hypothesis for the Student's t-test was:

$$H_0: B_i = 0$$
$$H_1: B_i \neq 0$$

The assumptions concerning the residuals as listed on page 341 of the Statistical Package of the Social Sciences (SPSS), 2nd ed., and the problems of heteroscedasticity, autocorrelation, and multicollinearity are addressed in the analysis of the model's output.

Test of Sample Differences

Our third objective was to test whether or not there was any statistically significant difference between the population of controllers cited as cause factors, and the situational variables affecting those records, and the population of HATRs caused by other than ATC controllers (pilots, material, etc.). The hypothesis was that there is no difference.

$$H_0: \mu_1 = \mu_2$$

$$H_1: \mu_1 \neq \mu_2$$

where μ_1 = those controllers cited as cause, and

μ_2 = those controllers listed in HATRs caused by pilots, etc. The test statistic was:

$$(\mu_1 - \mu_2) = (X_1 - X_2) \pm t_{.025} \sqrt{\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}}$$

After drawing a twelve-month sample randomly from each population, the means, variances, and standard deviations of each of the variables (total experience, facility experience, local experience, crew chief, weather, traffic density, trainee, equipment status, and emergency declaration) were computed. The means and variances of the nominal level data were computed using

one standard deviation. An F-test of the variances was accomplished to see if the variances were equal to validate the t-test. The hypothesis was that there is no difference. That is:

$$H_0: \sigma_1^2 = \sigma_2^2$$

$$H_1: \sigma_1^2 \neq \sigma_2^2$$

Should H_0 be rejected, the Behrens-Fischer approximation for the degrees of freedom would be employed in the test statistic. The approximation is:

$$\text{Degrees of Freedom} = \frac{\left(\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}\right)^2}{\frac{\left(\frac{s_1^2}{n_1}\right)^2}{n_1 - 1} + \frac{\left(\frac{s_2^2}{n_2}\right)^2}{n_2 - 1}}$$

By accomplishing the above tests, the researchers were able to infer whether or not the controllers having the HATRs were from the same population as those controllers not having HATRs.

Once the above mentioned tests were completed, the identical procedure was used to test whether or not there was a statistically significant difference between the experience levels of the 203 controllers listed as cause factors of their HATRs and the experience level of

the 279 controllers cited in those HATRs but not as the cause of the HATR. Again the hypothesis was that there is no difference.

$$H_0: \quad \mu_1 = \mu_2$$

$$\mu_1 \neq \mu_2$$

where:

μ_1 = the experience levels of those controllers cited as cause, and

μ_2 = the experience level of those controllers cited as non-cause.

The test statistic was:

$$\mu_1 - \mu_2 = \bar{X}_1 - \bar{X}_2 \pm t_{.025} \sqrt{\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}}$$

The validity of the t-test was insured by using the F statistic to compare the variances in the form of the hypothesis that there is no difference.

$$H_0: \quad \sigma_1^2 = \sigma_2^2$$

$$H_1: \quad \sigma_1^2 = \sigma_2^2$$

Should the variances prove unequal, the Behrens-Fischer approximation cited previously can be used to compute the degrees of freedom for the t-test.

In conclusion, the overall purpose of the authors' methodology was to determine whether or not a significant relationship existed between the experience levels of air traffic controllers and the number of reported HATRs. The trend analysis verified whether or not experience had declined over the 1975-78 time frame, but cannot be used for inference. The multiple linear regression depicted the number of HATRs as a function of the controller experience levels, and showed the contribution of the individual regressors. The t-test of the samples of the populations was used to identify any statistically significant differences between the experiece levels of those controllers cited as cause of HATRs and the experience levels of those controllers cited as non-cause. The descriptive statistics showed which combination of situational variables presented the highest percentage of appearences. The results of the above tests were reviewed in the analysis and showed what factors were significant to the situation resulting in a HATR. The analysis is contained in the following chapter.

CHAPTER IV

ANALYSIS OF RESULTS

Introduction

This chapter contains the results of our analysis on the objectives cited in Chapter III. It is broken into three major sections, one each on trend analysis, multiple linear regression, and the t-statistics on the comparison of means. Each section is further subdivided to cover the results of each test performed. Trend analysis is covered in four sections: trend lines and characteristics, the distribution of HATRs by experience levels, the distribution of the situational or categorical variables, and the proportions. The proportional analysis considers those controllers who had no previous experience, those with previous experience in the same type facility in which they received a HATR, and those with previous experience in other types of facilities. The second section of this chapter contains the analysis of the multiple regression, and the final section contains the analysis of the controller cause/noncause populations, and the comparison of each experience level and situational variable between the sample of data records on HATRs caused by ATC contollers and data records of HATRs caused by other sources,

The data file on which the analysis was conducted consisted of 488 HATRs that occurred over the period January 1975 through June 1978. Of these, 203 identified the controller as a first, second, or tertiary cause factor. The assignment of controller cause was accomplished by Headquarters AFCS, and was indicated on the HATR record in field 10, (see Appendix G). Where more than one controller was listed in the HATR summary, a determination of specific attribution was made by the authors based on phase of flight, positions of operation, and other relevant details as described in the HATR summary. This resulted in 228 controllers being identified as responsible for the 203 HATRs with twenty-five having no experience data. [Several HATRs listed both Precision Approach Radar (PAR) arrival and control tower personnel.] In final form, the file identified 228 controllers as cause factors, with twenty-five not having experience levels but having all the other necessary information.

For the remaining 279 controllers identified, the following assumptions were used throughout this analysis: the controllers identified in the HATR but not identified as the individual causing the hazard were assumed to be independent of the event. The identification of other than cause factors controllers forms a sample against which the cause factor population may be compared.

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The statistical data on the files was developed through the use of a utility program, TCAST (time series analysis), and through the use of linear regression both available on the CREATE system. A summary of the files and characteristics may be found in Table 4.

A plot of the number of HATRs over time revealed a slope of -.0893058 with a mean and standard deviation of 5.65 and 3.10128 (see Figure 4). In testing the null hypothesis, that the slope equaled zero, where:

$$H_0: \beta = 0$$
$$H_1: \beta \neq 0$$

the authors were able to reject H_0 at the 95 percent CI. This indicated that the number of HATRs attributable to ATC controllers was decreasing over the time period covered in the analysis.

A least squares line of best fit was developed through the data points resulting from plotting the HATRs by experience level over time. The results were trend lines indicating the general tendency of the data over time. The first analysis was on all controllers (HATRFIL, 482 cases). The resulting lines were (see Figure 5).

Total Experience (XT) $\hat{y} = 58.006 + .0140612X$

Facility Experience (XF) $\hat{y} = 40.768 + .003253X$

Local Experience (XL) $\hat{y} = 16.195 + .01465X$

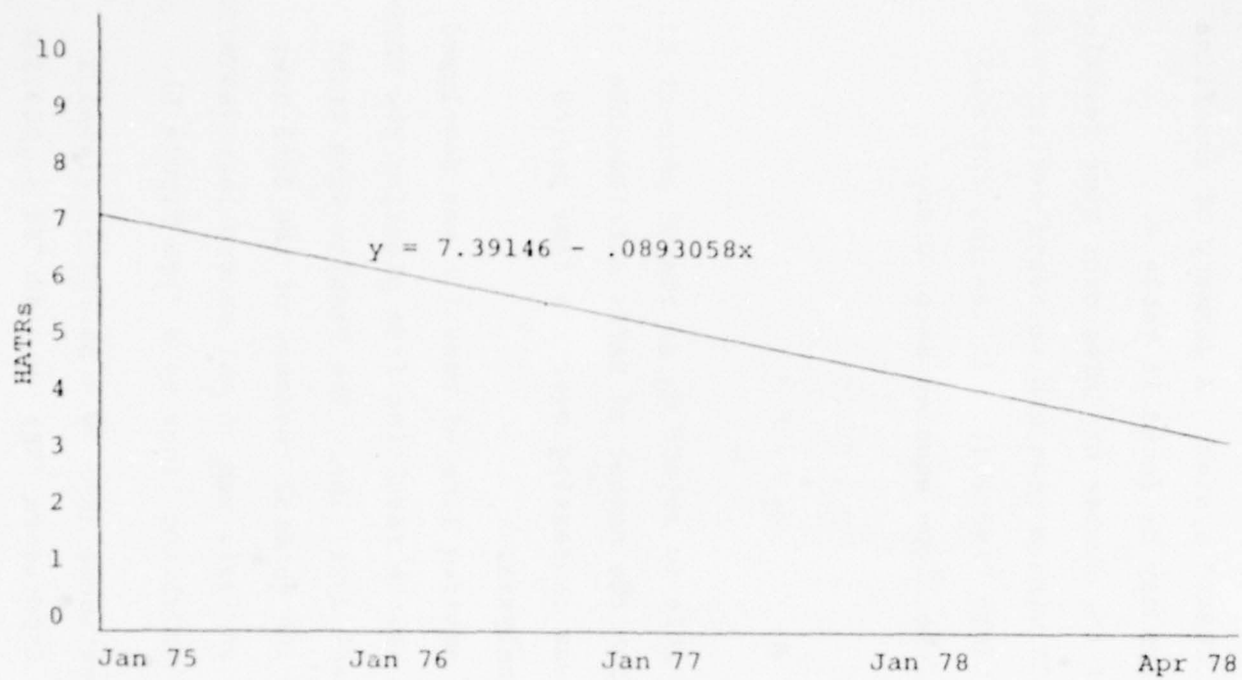

Fig. 4. Trend Line, Controller Caused HATRs Per Month

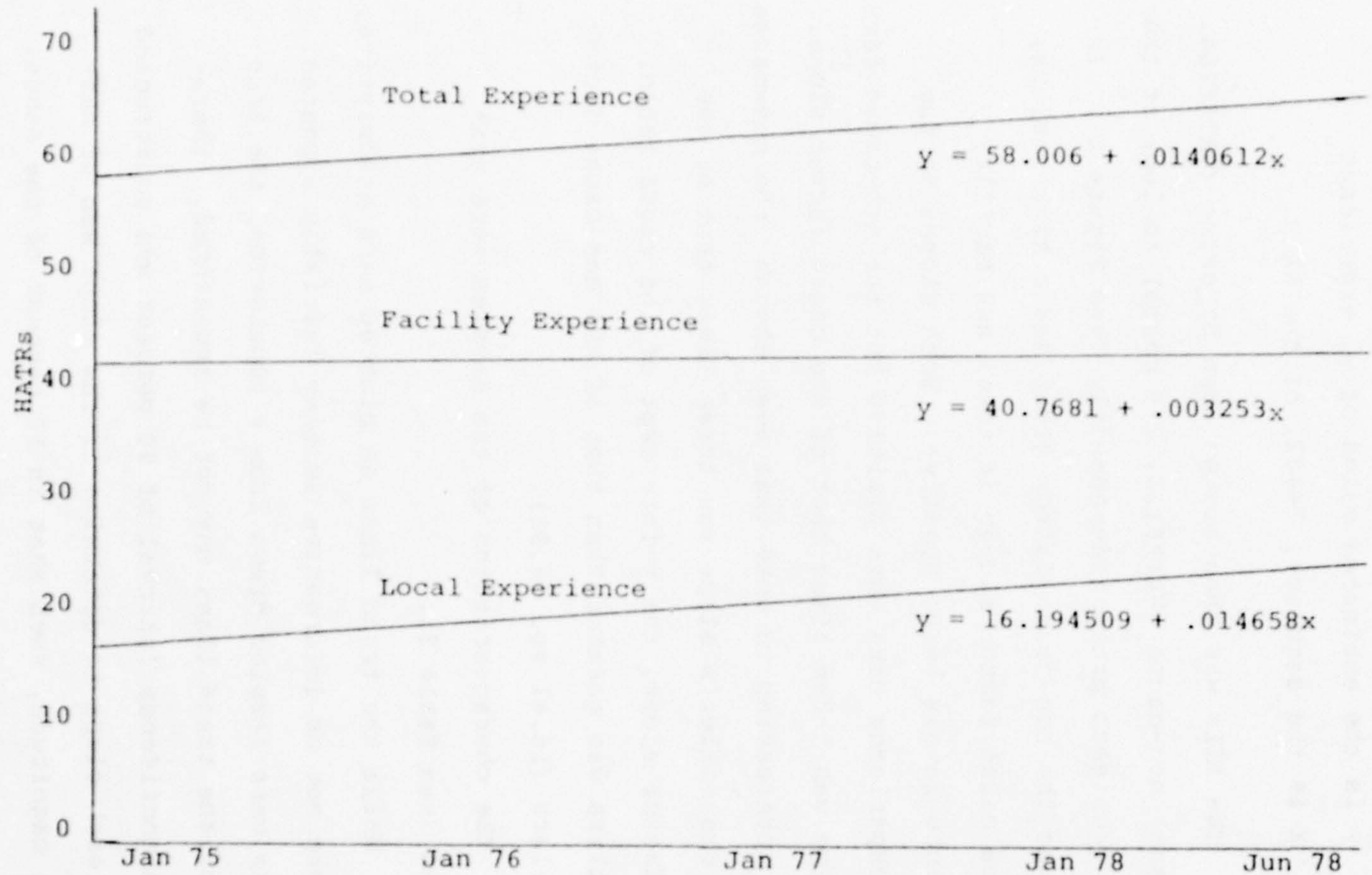

Fig. 5. Trend Lines, All Controllers

where:

$\hat{y}$ is the estimated value of y, experience

X is the sequence, 1-482, of the HATR.

The file was then broken down by cause (HATRFIL4, 203 cases) non-cause (HATRFIL2, 279 cases) to look at the trends from each group independently (see Figure 6). In each case the non-cause factor group had a higher slope, with the cause factor slopes in total and facility experience levels being negative. Both slopes in the local experience data were positive but the non-cause factor slope was three times that of the cause factor slope. It was interesting to note that even though the non-cause factor controller's slope was three times that of the cause factor slope, the y-intercept of the cause factor controllers was greater than that of the non-cause factor controllers (16.61 vs. 16.95).

The characteristics of the samples were next computed (see Table 3).

While the trend lines as plotted were descriptive, they were not as informative as they initially appeared. As these were samples drawn from a population, the true value of the trend lines may not be repesented. Therefore, a confidence interval of 90 percent was constructed around each slope to determine if the slope was of sufficient magnitude, such that in 90 percent of the cases,

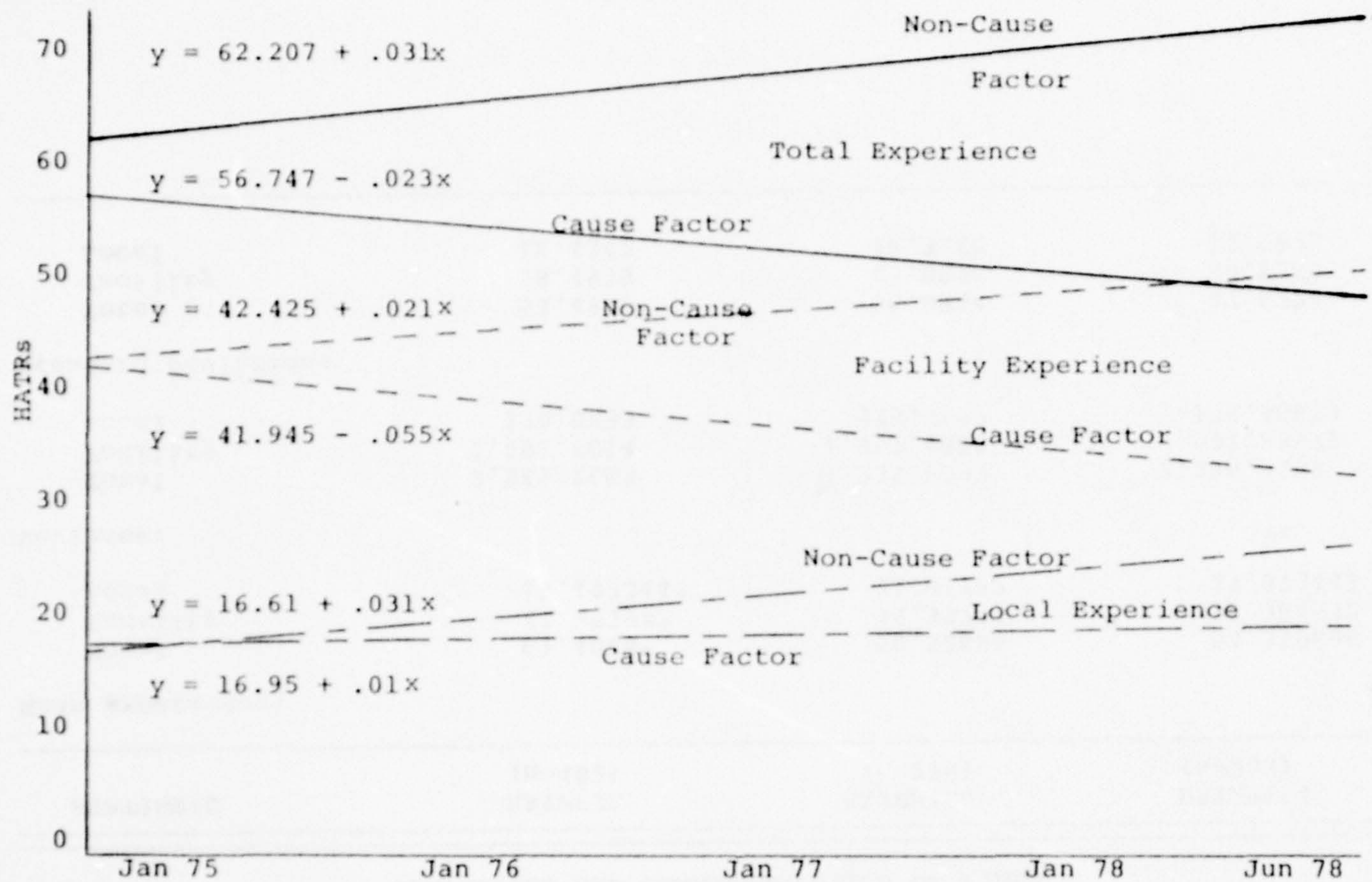

Fig. 6. Experience, Cause vs Non-Cause

TABLE 3

STATISTICS AND CHARACTERISTICS OF FILES

STATISTIC	HATRFIL (n=482)	HATRFIL2 (n=279)	HATRFIL4 (n=203)
Mean Experience:			
Total	61.40249	66.52688	54.359606
Facility	41.553942	45.39749	36.364532
Local	19.1973444	21.01792	17.970443
Variance:			
Total	2,861.2663	3,235.8397	2,286.9889
Facility	1,481.7814	1,857.4066	931.88572
Local	270.0833	335.9527	176.56629
Standard Deviation:			
Total	53.4908	56.8844	47.8224
Facility	38.4939	43.0976	30.5268
Local	16.4342	18.3240	13.2878

the interval would not contain zero. If the interval contained zero, we would fail to reject the null hypothesis that β, the slope, equals zero.

$$H_0: \beta = 0$$

$$H_1: \beta \neq 0$$

If we rejected the null hypothesis that the interval did not contain zero, we could say with 90 percent confidence that the slope was not equal to zero and that the most likely value for the slope to was the computed value.

The confidence interval for the slope was determined by the equation:

$$\beta = \hat{\beta} \pm Z_{.10} \frac{S}{\sqrt{\Sigma x_i^2}}$$

where:

β is the true slope.

$\hat{\beta}$ is the computed value of the slope from the sample.

$Z_{.10}$ is the Z value for a 90 percent confidence level.

S is the square root of the residual variance, and

ΣX_i^2 is the sum of $(X-\bar{X})^2$ from the sample.

The specific tests for HATRFIL (all controllers), HATRFIL2 (non-cause controllers), and HATRFIL4 (cause controllers) follow. Each file broken down into total experience (XT), facility experience (XF), and local experience (XL).

HATRFIL: (482 cases) XT

$$= .0140612 \pm .0288049^{*}$$

$$-.0147437 \leq \hat{\beta} \leq .0428661$$

The interval contains zero, therefore it fails to reject H_0.

HATRFIL: XF

$$= .00325307 \pm .020729$$

$$-.017476 \leq \hat{\beta} \leq .023982$$

The interval contains zero, therefore fail to reject H_0.

HATRFIL: XL

$$= .01465808 \pm .0088498$$

$$.0058082 \leq \hat{\beta} \leq .0235078$$

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*Computed from 1.645 $S/\sqrt{\Sigma X^2_i}$ in each case [90 percent Confidence Internal (CI)].

Reject H_0, the interval does not contain zero.

HATRFIL2: (279 cases) XT

$$= .0308534 \pm .0695579$$

$$-.031945 \leq \hat{\beta} \leq .0734495$$

Fail to reject H_0, the interval contains zero.

HATRFIL2: XF

$$.02075003 \pm .0526995$$

$$-.0319495 \leq \hat{\beta} \leq .0734495$$

Fail to reject H_0, the interval contains zero.

HATRFIL2: XL

$$= .03142647 \pm .0224065$$

$$.0090582 \leq \hat{\beta} \leq .0538712$$

Reject H_0 the interval does not contain zero.

HATFIL 4: (203 Cases) XT

$$= .0234083 \pm .0942213$$

$$-.070813 \leq \hat{\beta} \leq .1176296$$

Fail to reject H_0, the interval contains zero.

HATRFIL4: XF

$$= .05471502 \pm .0601449$$

$$-.0053947 \leq \hat{\beta} \leq .1148951$$

Fail to reject H_0, the interval contains zero.

HATRFIL4: XL

$$+ .0099182 \pm .0273434$$

$$-.0174252 \leq \hat{\beta} \leq .03726616$$

Fail to reject H_0, the interval contains zero.

The null hypothesis failed to reject in seven of the nine tests. In those cases that failed to reject we must accept the possibilty that the slope of the trend line may be zero and therefore the dependent variable, experience, may not be changing over time, or it may even be negative. In the two cases that did reject, local experience in both the combined and noncause factor samples, the slope was positive and indicated an increase in local experience in the noncause factor population.

During the period, the total number of hours flown by USAF aircraft decreased significantly according to the AF budgets for this period. What has the effect been on the traffic count as maintained in USAF Air Traffic Control facilities? A single takeoff or landing is counted for each flight operation on, or in the case of low approaches, over the airport. Assuming the traffic count in control towers is a measure of the interface between the controller and the flying customer, some consideration of the impact of the reduction in flying hours must be made. A sample of twenty USAF installations was

drawn at random with only one stipulation, that being no major mission change had taken place during the period. The bases were: Altus, OK; Barksdale, LA; Cannon, NM; Castle, CA; Davis-Monthan AZ; Eglin, FL; England, LA; Homestead, FL; Langley, VA; Little Rock, AK; Luke, AZ; McChord, WA; McClellan, CA; Moodey, GA; Myrtle Beach, SC; Patrick, FL; Robins, GA; Shaw, SC; Tyndall, FL; and Wright-Patterson, OH. (As it developed one base, Moody AFB, Georgia, was included erroneously. The traffic count dropped from an average quarterly value of 17,193 operations per quarter in quarters 3/75, 4/75, and 1/76 to an average of 6,746 operations for quarters 2/76, 3/76, and 4/76. As the values remained steady over the next eleven quarters, it was determined that the effect was minimal and the information was retained in the computations.)

All the traffic count data was taken from the AFCS quarterly traffic count reports for the periods 3/75 through 1/79. The total traffic count for each of the twenty bases in each quarter was summed and a mean developed for the quarter. This was done over sixteen quarters to develop sixteen data points for analysis. The mean traffic per quarter over the period was 469,347.69 operations per quarter with a variance of 1,027,950,800 and standard deviation of 32,061,672. The regression line was:

$$\hat{\beta} = 468951.25 + 3.8866X$$

Testing the hypothesis that $\beta = 0$, that is, the slope of the line was zero, yielded the following interval at the 90 precent confidence level:

$$= 3.8866 \pm 239.44$$

$$-235.55 \leq \hat{\beta} \leq 243.32$$

Therefore, we were unable to reject H_0 and must consider that though total flying hours has decreased, total traffic count, the measure of the controller/pilot interface, has not changed substantially.

Distribution of HATRS by Experience

A table of experience levels for all 482 controllers was developed. When broken into year groups, these tables revealed that of all controllers identified, 54.356 percent were under four years total experience and 70.33 percent were under six years. When plotted by facility experience we find that 67.1 percent are under four years experience in that type facility and 82.36 percent were under six years (see Table 4).

When the files were broken out by total experience, cause vs. non-cause factor, we found that 51.97 percent were under four years, and 65.94 percent were under six years for the non-cause factors. A percentage of 58.120 under four years, and 76.84 percent under six years were noted for cause factors. Comparing the two groups by

TABLE 4

HATRs BY EXPERIENCE, ALL CONTROLLERS
(482 cases--File name: HATRFIL)

MONTHS	TOTAL EXPERIENCE	CUM. %	FACILITY EXPERIENCE	CUM. %	LOCAL EXPERIENCE	CUM. %
0-12	54		92		182	
13-24	76	26.97%	111	42.11%	13Ø	64.73%
25-36	74		74		77	
37-48	55	53.73%	46	67.01%	34	87.75%
49-60	35		39		18	
61-72	42	69.70%	34	82.15%	6	92.73%
73-84	3Ø		24		5	
85-96	25		15		Ø	
97-108	16		6		1	
109-120	12		11		Ø	
121-132	12		4		Ø	
133-144	9		2		Ø	
145-156	6		4		Ø	
157-168	7		5		Ø	
169-180	6		Ø		Ø	
181-192	3		1		Ø	
193-204	2		1		Ø	
205-216	3		1		Ø	
217-228	Ø		Ø		Ø	

TABLE 4--Continued

MONTHS	TOTAL EXPERIENCE	CUM. %	FACILITY EXPERIENCE	CUM. %	LOCAL EXPERIENCE	CUM. %
229-240	4		1		Ø	
241-252	2		1		Ø	
253-264	1		Ø		Ø	
265-276	Ø		Ø		Ø	
277-288	1		Ø		Ø	
289-300	2		Ø		Ø	

facility experience we found that 62.36 percent of the non-cause factor controllers were under four years experience, and 76.70 percent were under six years experience. For the cause factor controllers the figures were 73.39 percent under four years experience, and 89.16 percent under six years experience. When the local experience levels were considered we found 79.92 percent were under four years and 87.45 percent were under six years experience for the non-cause factor groups. Analysis of the cause factor group revealed that 98 percent of the controllers in that group were under four years and 99 percent (201/203) were under six years.

Looking only at the two year level, we found that while 54.48 percent of the non-cause factor controllers had two years or less local experience in the facility where the HATR occurred, 78.32 percent of the cause factor controllers had two years or less experience in the facility (see Tables 5 and 6).

A test to determine if there was a signficant difference between the means of the samples was performed later in this analysis.

The Categorical Variables

An analysis was made of the 203 cases that had full categorical data (i.e., crew chief, weather, traffic, trainee, and equipment failure). For this analysis four

TABLE 5

HATRs BY EXPERIENCE NONCAUSE FACTOR
(279 cases--File name: HATRFIL2)

MONTHS	TOTAL EXPERIENCE	CUM. %	FACILITY EXPERIENCE	CUM. %	LOCAL EXPERIENCE	CUM. %
0-12	29		44		86	
13-24	42	25.44%	60	37.27%	66	54.48%
25-36	44		46		55	
37-48	30	51.97	24	62.36%	16	79.92%
49-60	17		21		15	
61-72	22	65.94%	19	76.70%	6	87.74%
73-84	19		15		3	
85-96	16		12		0	
97-108	8		3		1	
109-120	9		9		0	
121-132	9		2		0	
133-144	5		1		0	
145-156	4		3		0	
157-168	7		4		0	
169-180	5		0		0	
181-192	3		1		0	
193-204	2		1		0	
205-216	3		1		0	

TABLE 5--Continued

MONTHS	TOTAL EXPERIENCE	CUM. %	FACILITY EXPERIENCE	CUM. %	LOCAL EXPERIENCE	CUM. %
217-228	Ø		Ø		Ø	
229-240	2		1		Ø	
241-252	2		1		Ø	
253-264	1		Ø		Ø	
265-276	Ø		Ø		Ø	
277-288	Ø		Ø		Ø	
289-300	1		Ø		Ø	

TABLE 6

HATRs BY EXPERIENCE, CAUSE FACTOR
(203 cases--File name: HATRFIL4)

MONTHS	TOTAL EXPERIENCE	CUM. %	FACILITY EXPERIENCE	CUM. %	LOCAL EXPERIENCE	CUM. %
0-12	29		49		96	
13-24	34	31.03%	51	49.26%	63	78.32%
25-36	3Ø		27		22	
37-48	25	58.12%	22	73.39%	18	98.02%
49-60	18		18		2	
61-72	2Ø	76.84%	14	89.16%	Ø	99.01%
73-84	12		9		2	
85-96	9		3		Ø	
97-108	8		3		Ø	
109-120	3		2		Ø	
121-132	3		2		Ø	
133-144	4		1		Ø	
145-156	2		1		Ø	
157-168	2		Ø		Ø	
169-180	1		Ø		Ø	
181-192	Ø		Ø		Ø	
193-204	Ø		Ø		Ø	
205-216	Ø		Ø		Ø	

TABLE 6--Continued

MONTHS	TOTAL EXPERIENCE	CUM. %	FACILITY EXPERIENCE	CUM. %	LOCAL EXPERIENCE	CUM. %
217-228	Ø		Ø		Ø	
229-240	2		Ø		Ø	
241-252	Ø		Ø		Ø	
253-265	Ø		Ø		Ø	
265-276	Ø		Ø		Ø	
277-288	1		Ø		Ø	
289-300	1		Ø		Ø	

cases were removed. The deleted controllers had in excess of 180 months total experience each and, due to the over fifteen years total experience were not characteristic of the population being viewed as a whole (13). A sixth variable, emergency, was considered but was dropped in this analysis due to only one occurrence. The five categorical elements yielded a potential thirty-two different combinations to be examined. Twelve of the combinations were dropped as they contained no occurrences. Ten more cases were dropped due to low frequency of occurrence resulting in ten situations. Table 7 contains information on all HATRs broken down by count and percentage. Figures 7 through 11 contain the distribution of HATRs by local experience for each of the situational variables.

Intuitively we felt that the best situation, one that would result in the least HATRs, would be one in which there was a crew chief assigned, VFR weather, light traffic, no trainee, and no equipment failure. There were thirty-eight HATRs that occurred with this situation (see Figure 12). The same situation except with heavy traffic resulted in forty-five HATRs (see Figure 13). The worse (intuitively) situation would be where there was no crew chief, IFR weather, heavy traffic, a trainee and equipment failure. There were no HATRs representing that combination of variables. These categorical variables,

TABLE 7

SITUATIONAL VARIABLES

		1	0	1	0	1	0	1	0	1	0	
		CC	$\overline{CC}$	VF	IF	LGT	HVY	TR	$\overline{TR}$	EQ	$\overline{EQ}$	TOTAL
1	CC			126	14	72	68	32	108	17	123	140
0	$\overline{CC}$			48	11	41	18	8	51	6	53	59
1	VF	63.3%	24%			98	76	36	138	22	152	174
0	IF	7%	5%			15	10	4	21	1	24	25
1	LGT	36.1%	20.6%	49.2%	7.5%			27	86	12	101	113
0	HVY	34.1%	9%	38.1%	5%			13	73	11	75	86
1	TR	16%	4%	18.1%	2%	13.6%	6.5%			2	38	40
0	$\overline{TR}$	54.3%	25.6%	69.3%	10.5%	43.2%	36.7%			21	138	159
1	EQ	8.5%	3%	11%	.5%	6%	5.5%	1%	10.5%			23
0	$\overline{EQ}$	61.8%	26.6%	77%	11%	50.7%	37.7%	19.1%	69.3%			176
TOTAL		140	59	174	25	113	86	40	159	23	176	199 199

Top Half = Number of Occurrences. Lower Half = % of Occurrences.

$\overline{CC}$ indicates no crew chief.

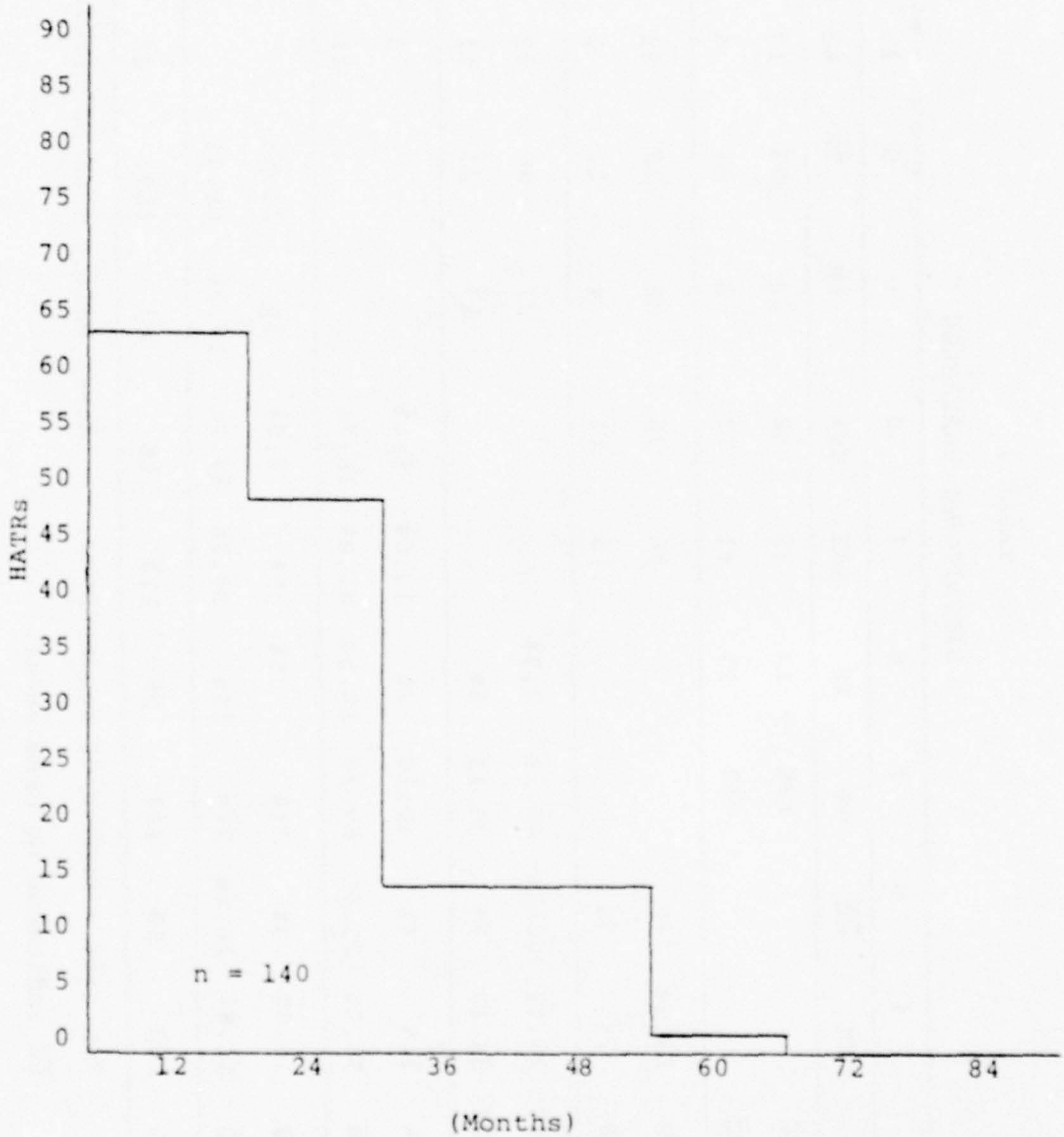

Fig. 7. Local Experience by Crew Chief

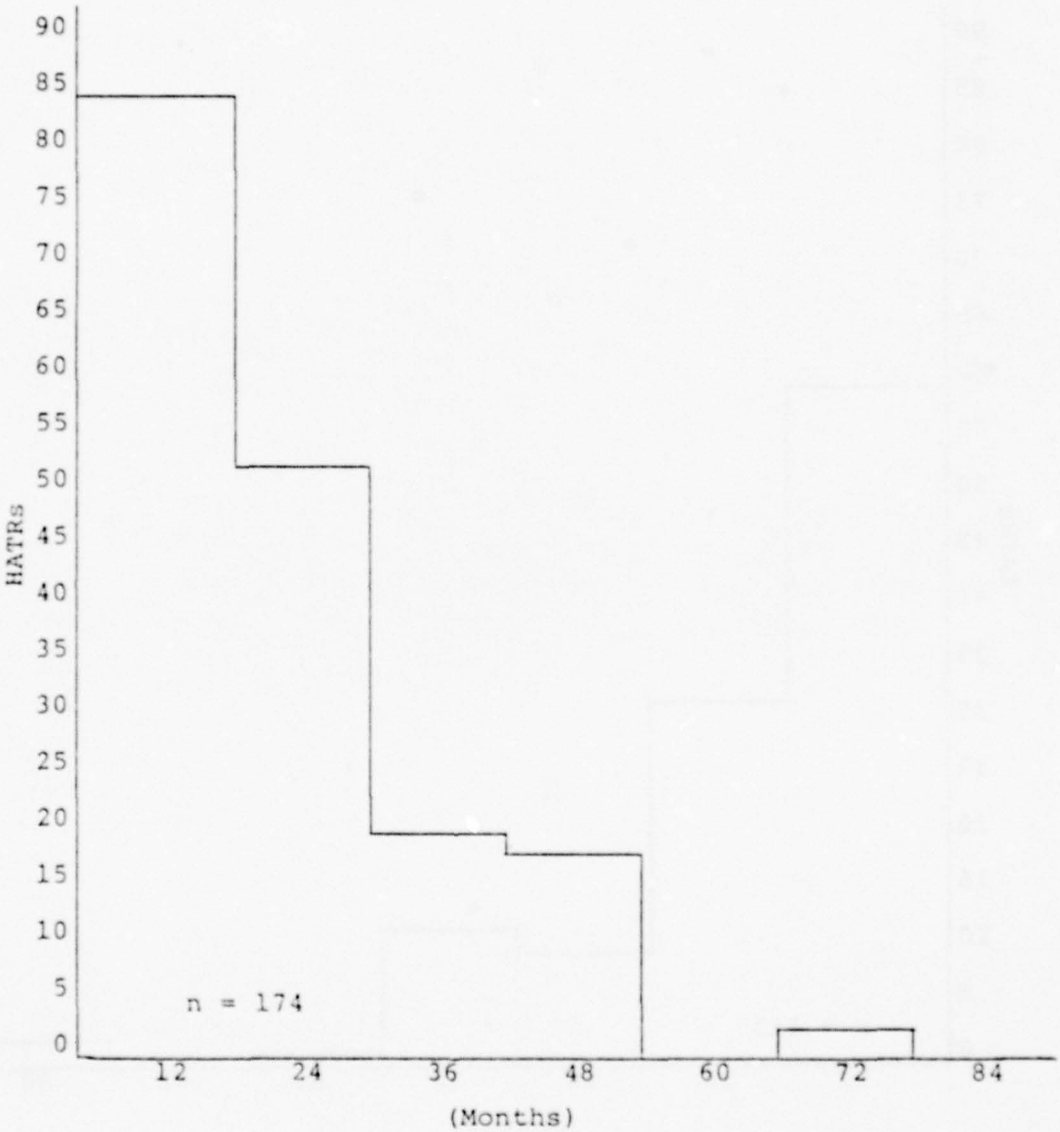

Fig. 8. Local Experience by VFR Weather

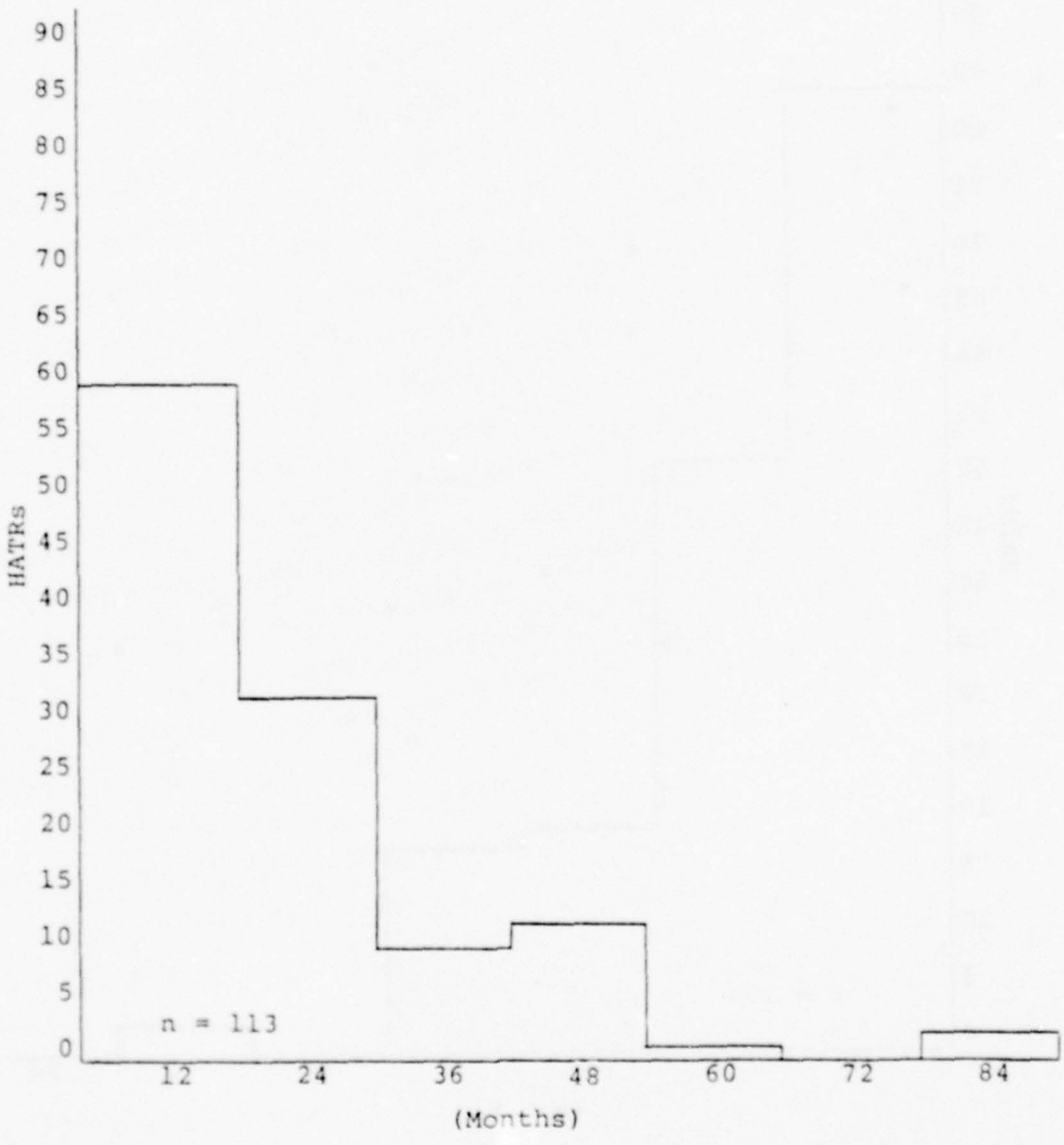

Fig. 9. Local Experience by Light Traffic

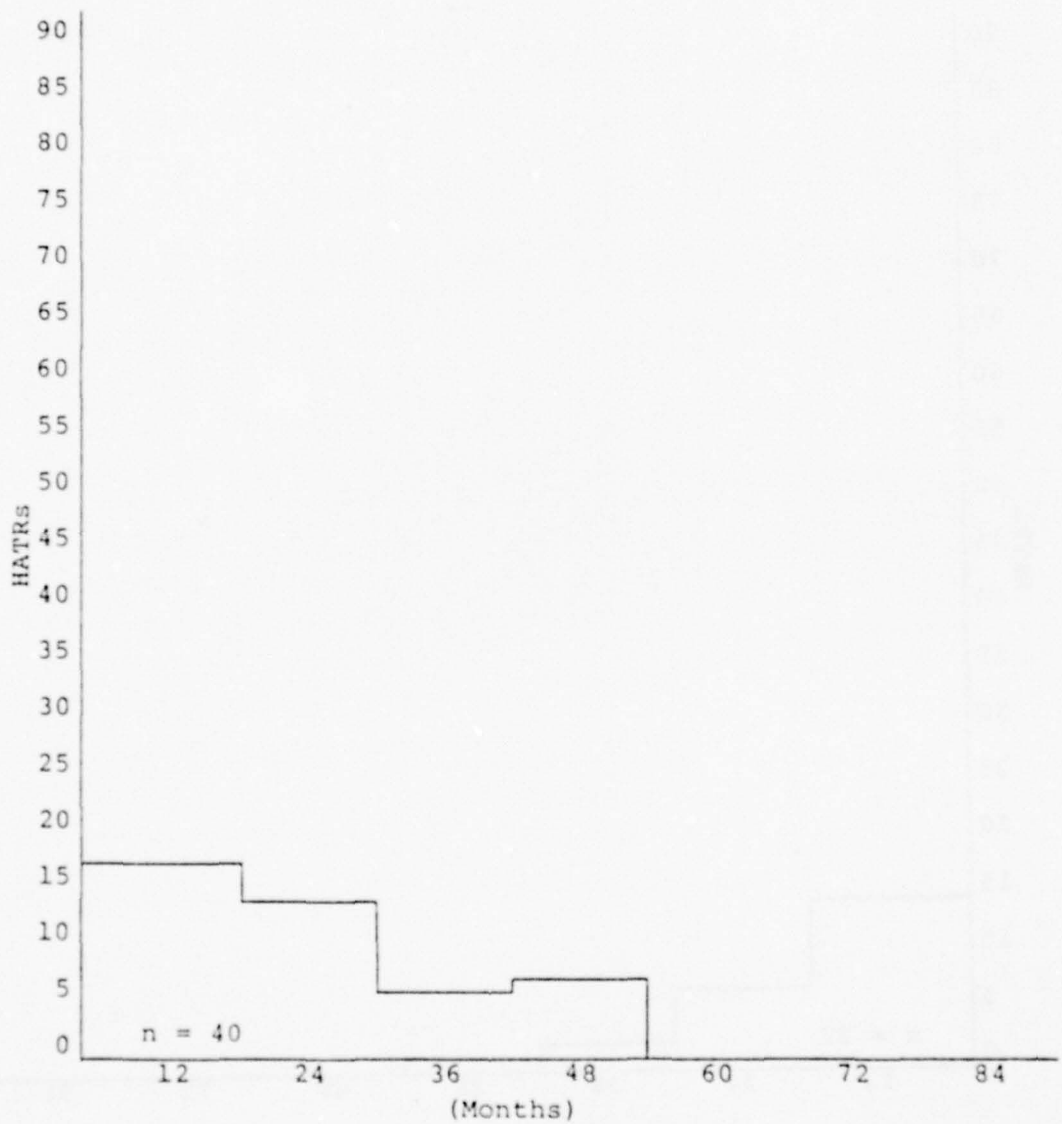

Fig. 10. Local Experience by Trainee

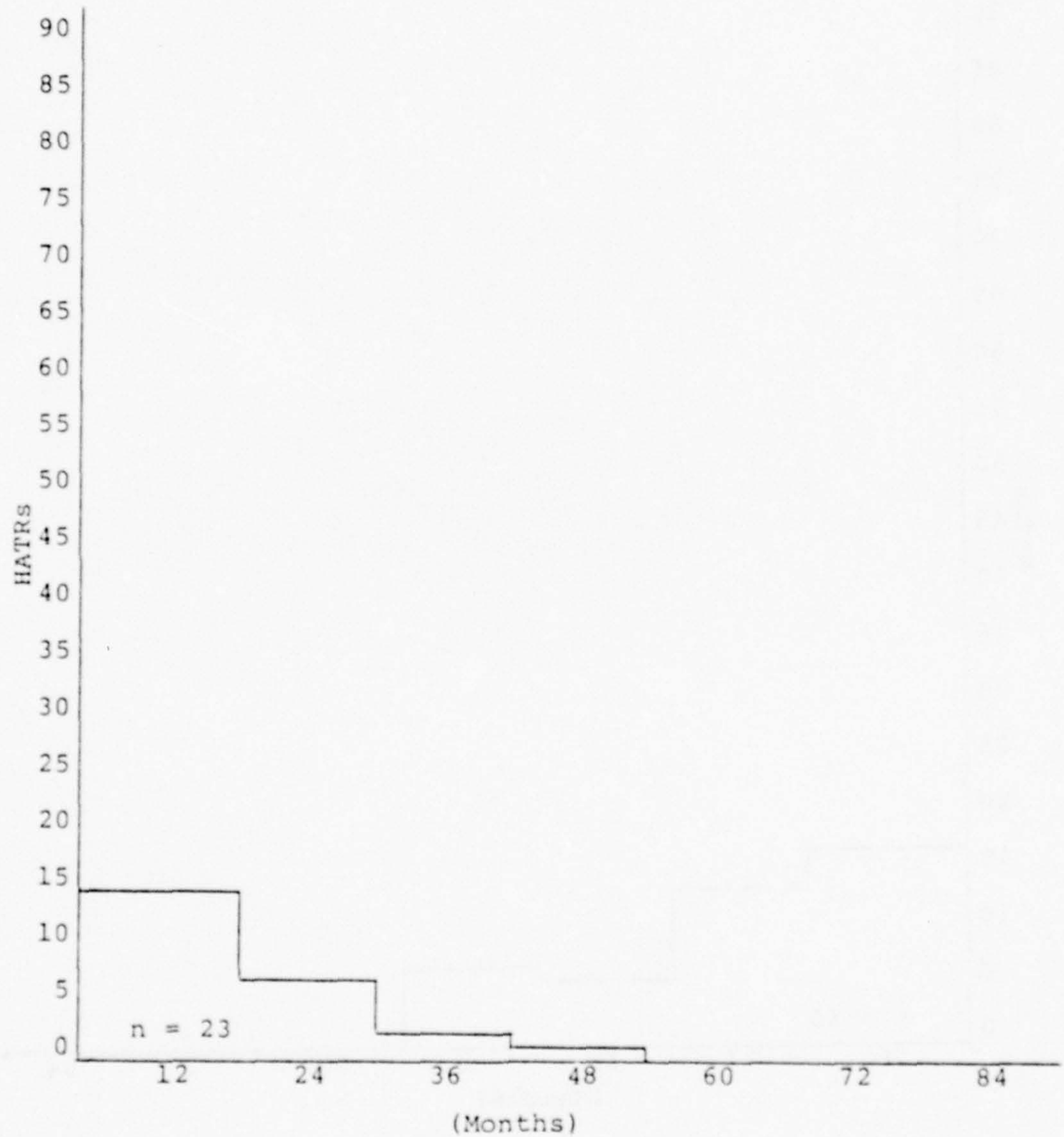

Fig. 11. Local Experience by Equipment Failure

plotted by local experience, are presented as Figures 12 through 21).

The Proportional Analysis

The data was examined as to the proportion of personnel having HATRs in their first experience in a facility of a specific type. This was deduceable from the data in that individuals having equal local and facility experience may be assumed to have achieved that experience level in the same facility. In cases where facility experience exceeded local experience the subject controller had had a previous tour in that type of facility.

Of the 203 cause factor controllers, 114 were on their first tour in that type of facility (56.1976 percent). Of the 279 non-cause factor controllers, 130 were on their first tour in that type of facility (46.595 percent). This indicated that of the non-cause factor controllers, 53.409 percent had previous experience in a facility of that type while only 43.842 percent of the cause factor controllers had previous experience.

Due to the relatively large size of the samples, a test for significance was accomplished. The test equation at 90 percent CI was:

$$P_1 - P_2 \pm Z_{.10}\sqrt{\frac{P_1(1-P_1)}{M_1} + \frac{P_2(1-P_2)}{M_2}}$$

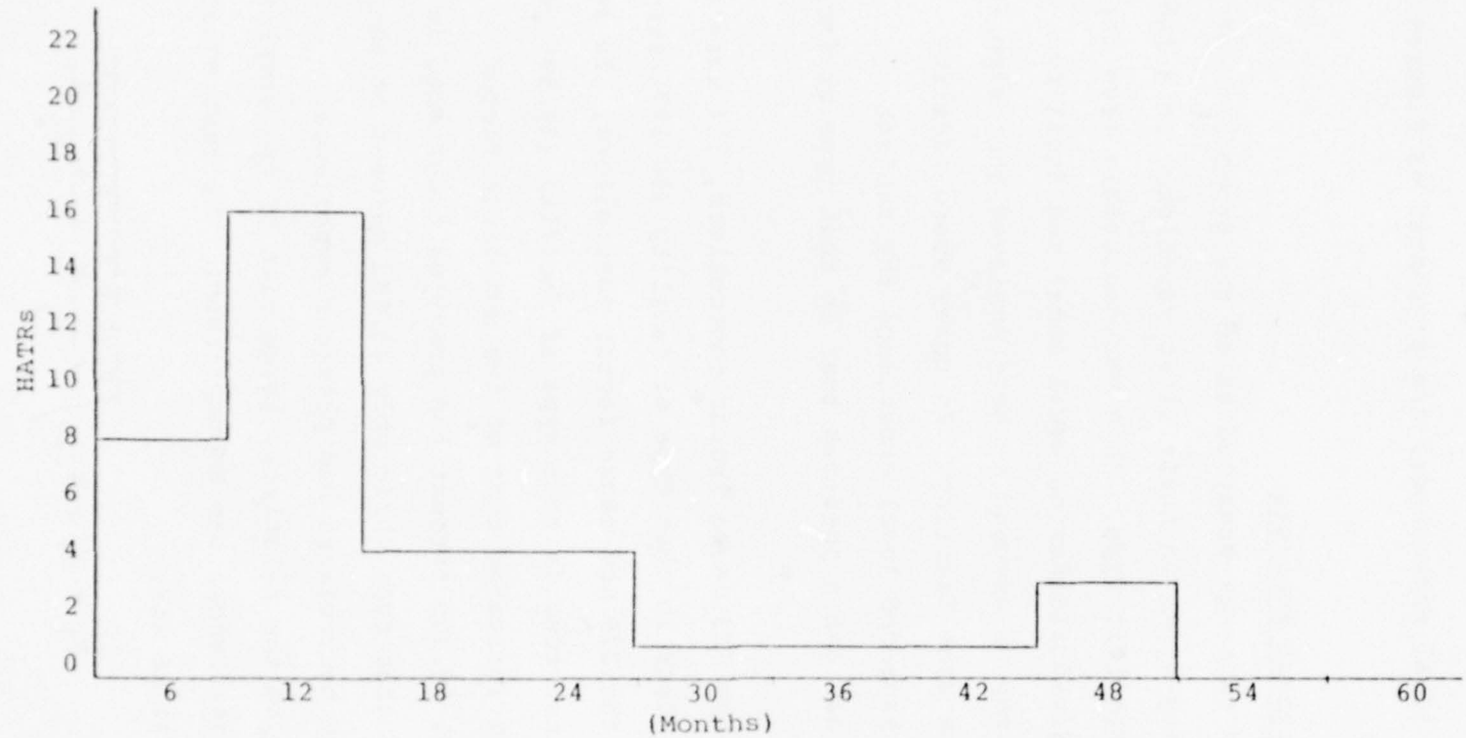

Fig. 12. HATRs By Local Experience, Categorical Variables: Crew Chief, VFR Weather, Light Traffic, No Trainee, No Equipment Failure, (38 cases)

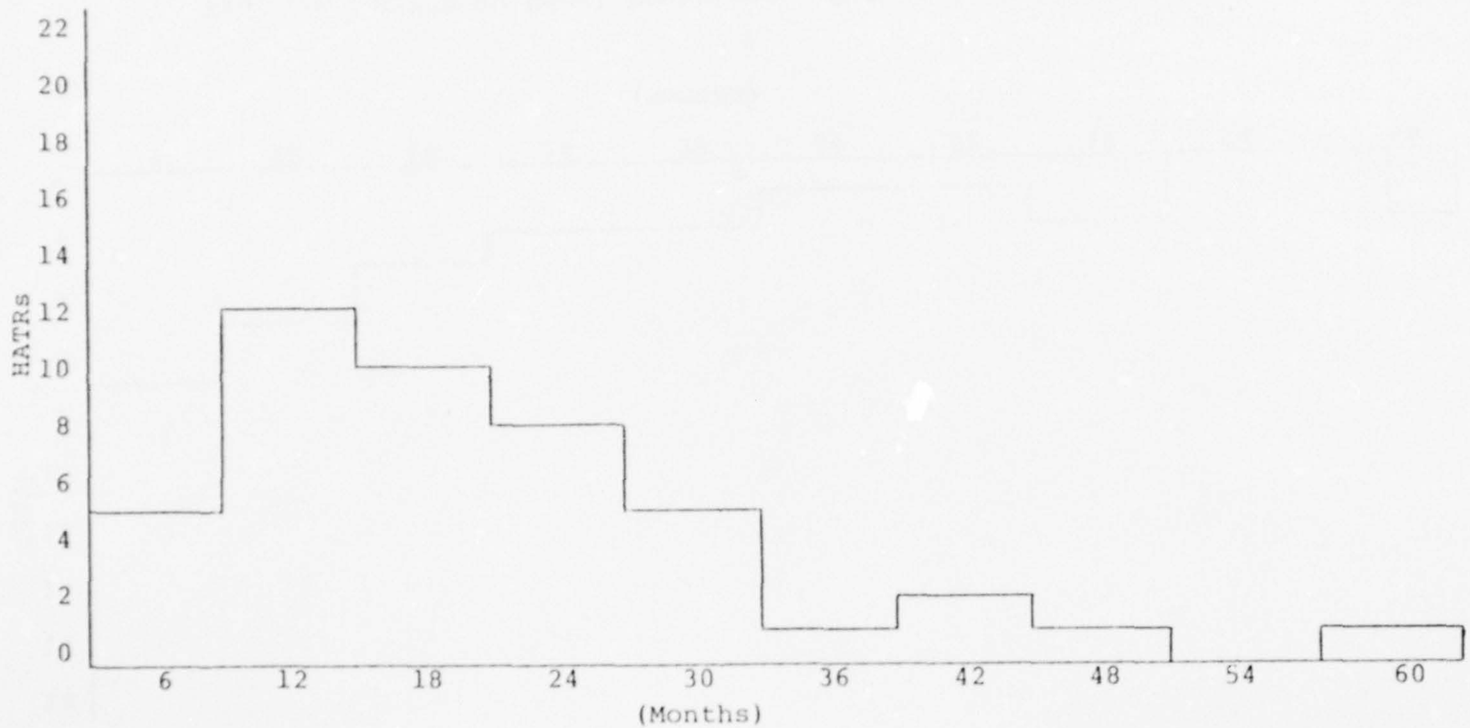

Fig. 13. HATRs By Local Experience, Categorical Variables: Crew Chief, VFR Weather, Heavy Traffic, No Trainee, No Equipment Failure, (45 cases)

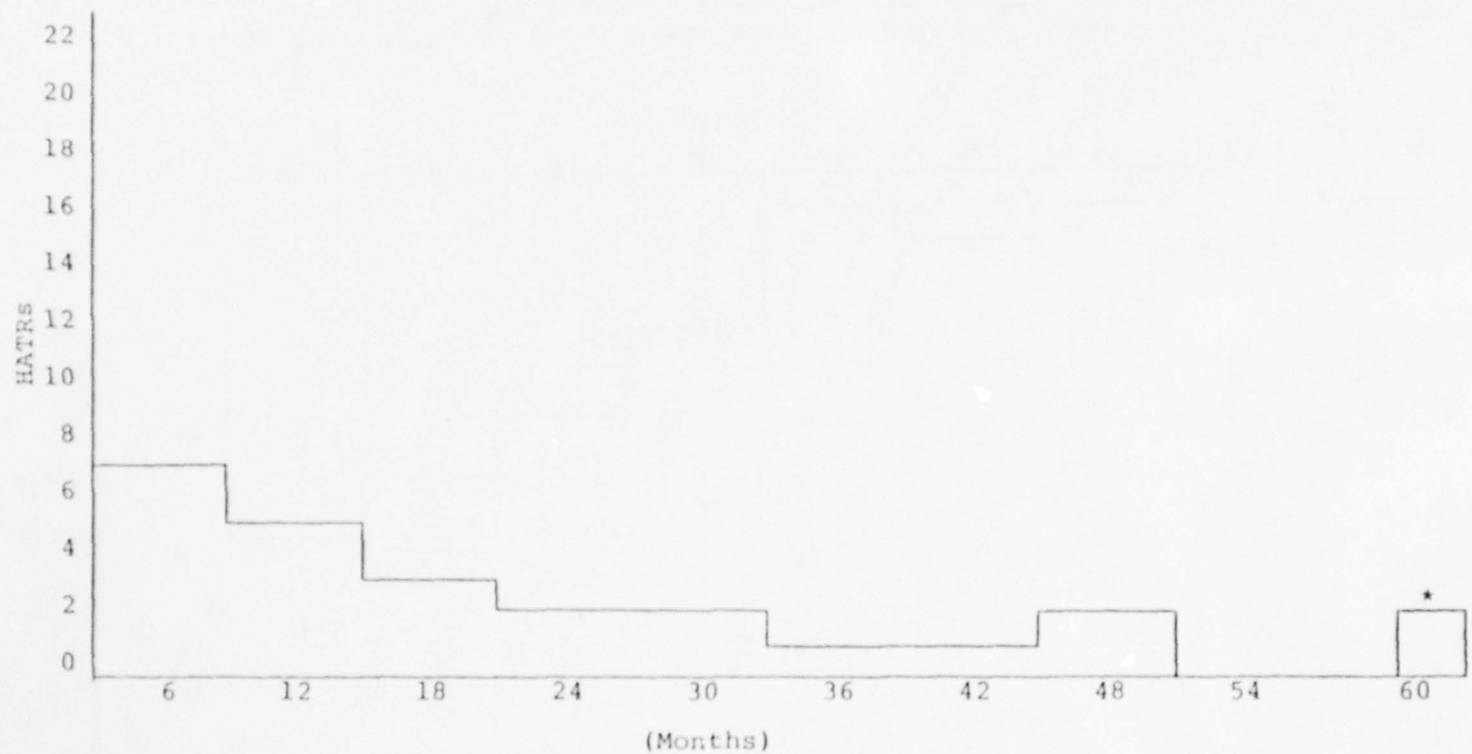

Fig. 14. HATRs By Local Experience, Cateogrical Variables: No Crew Chief, VFR Weather, Light Traffic, No Trainee, No Equipment Failure, (25 cases)

*Two HATRs greater than 70 months.

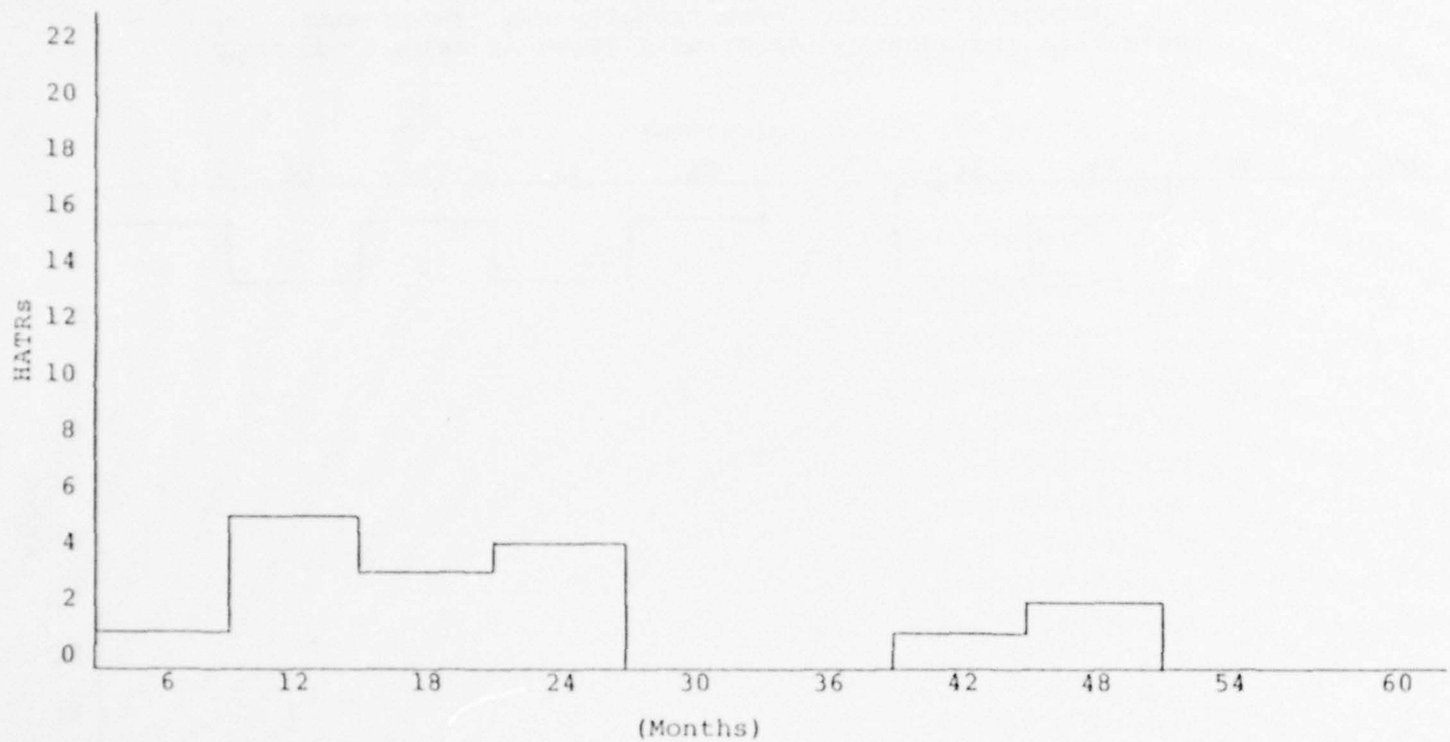

Fig. 15. HATRs By Local Experience, Categorical Variables: Crew Chief, VFR Weather, Light Traffic, Trainee, No Equipment Failure, (16 cases)

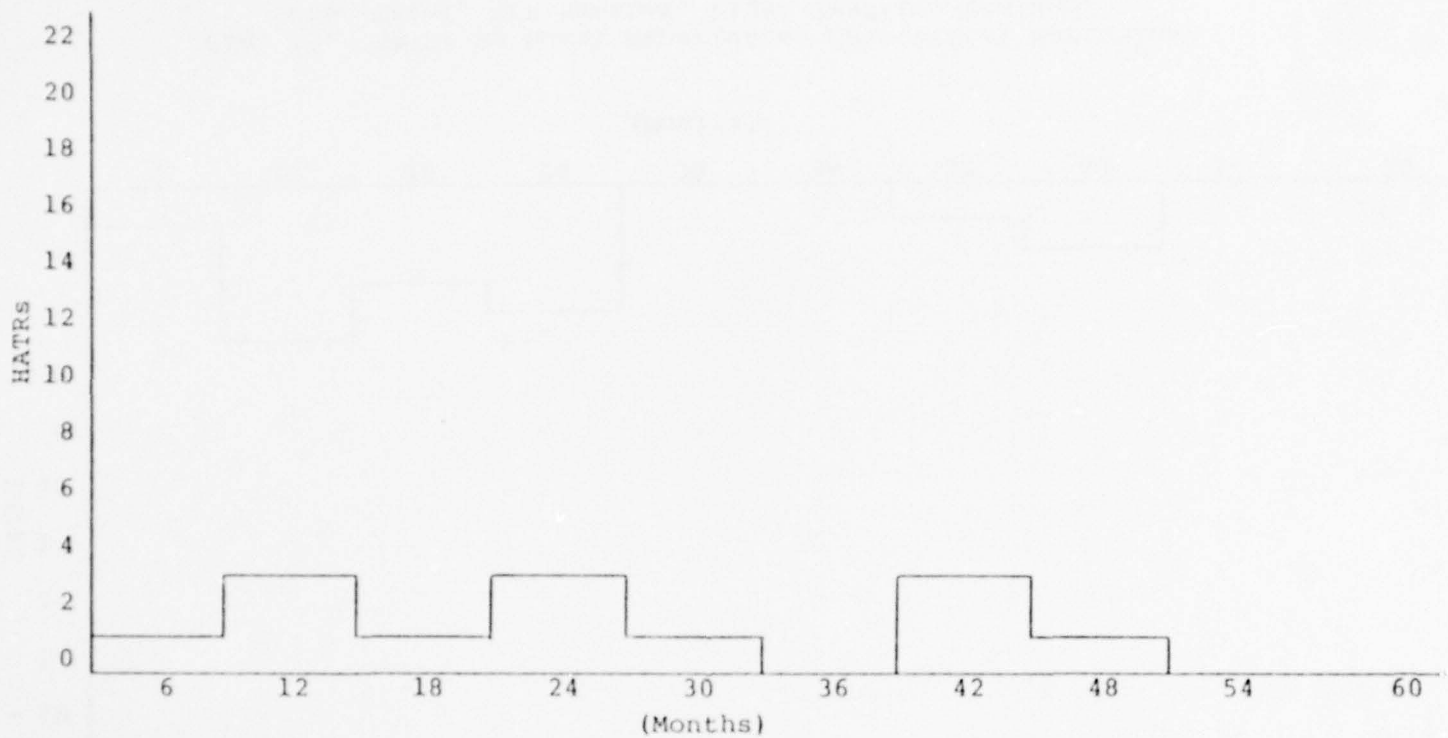

Fig. 16. HATRs By Local Experience, Categorical Variables: Crew Chief, VFR Weather, Heavy Traffic, Trainee, No Equipment Failure, (13 cases)

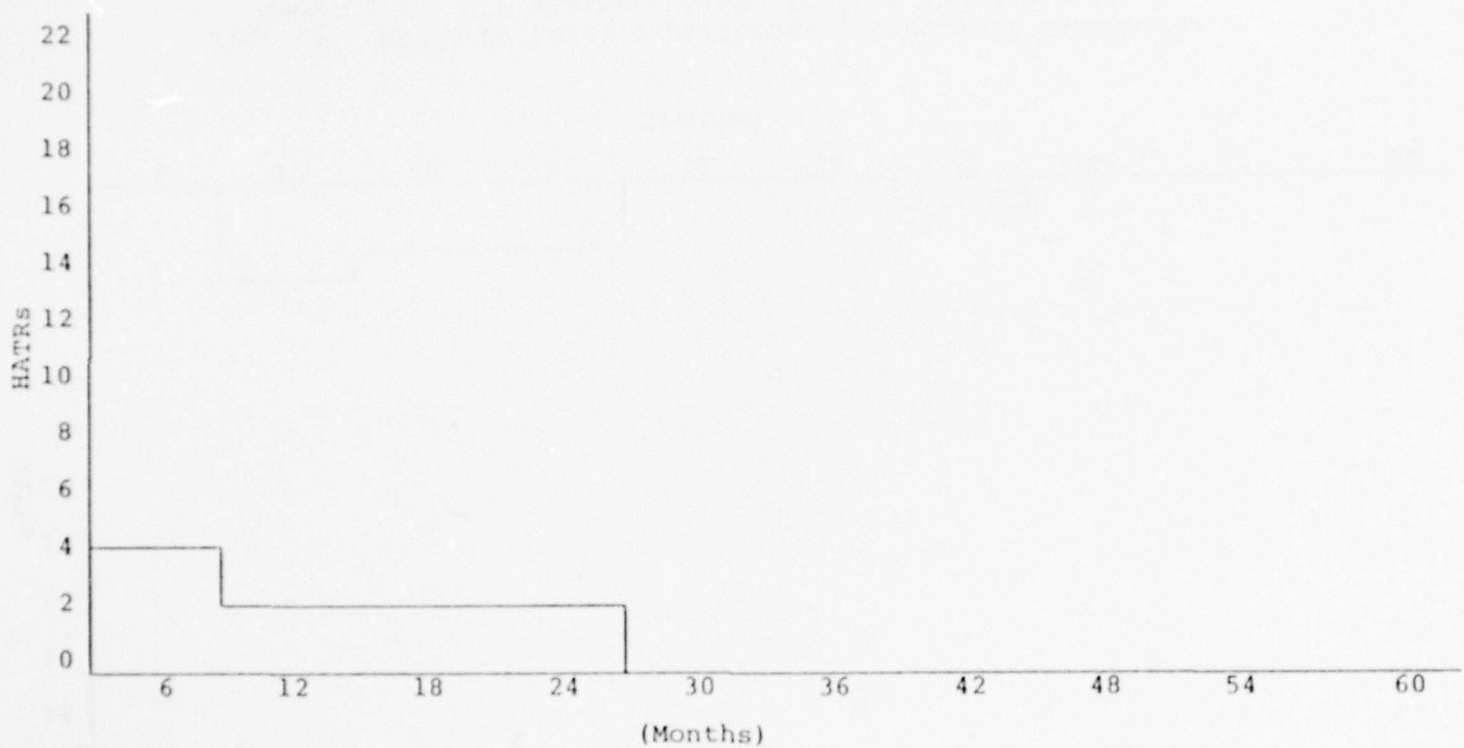

Fig. 17. HATRs By Local Experience, Categorical Variables: No Crew Chief, VFR Weather, Heavy Traffic, No Trainee, No Equipment Failure, (10 cases)

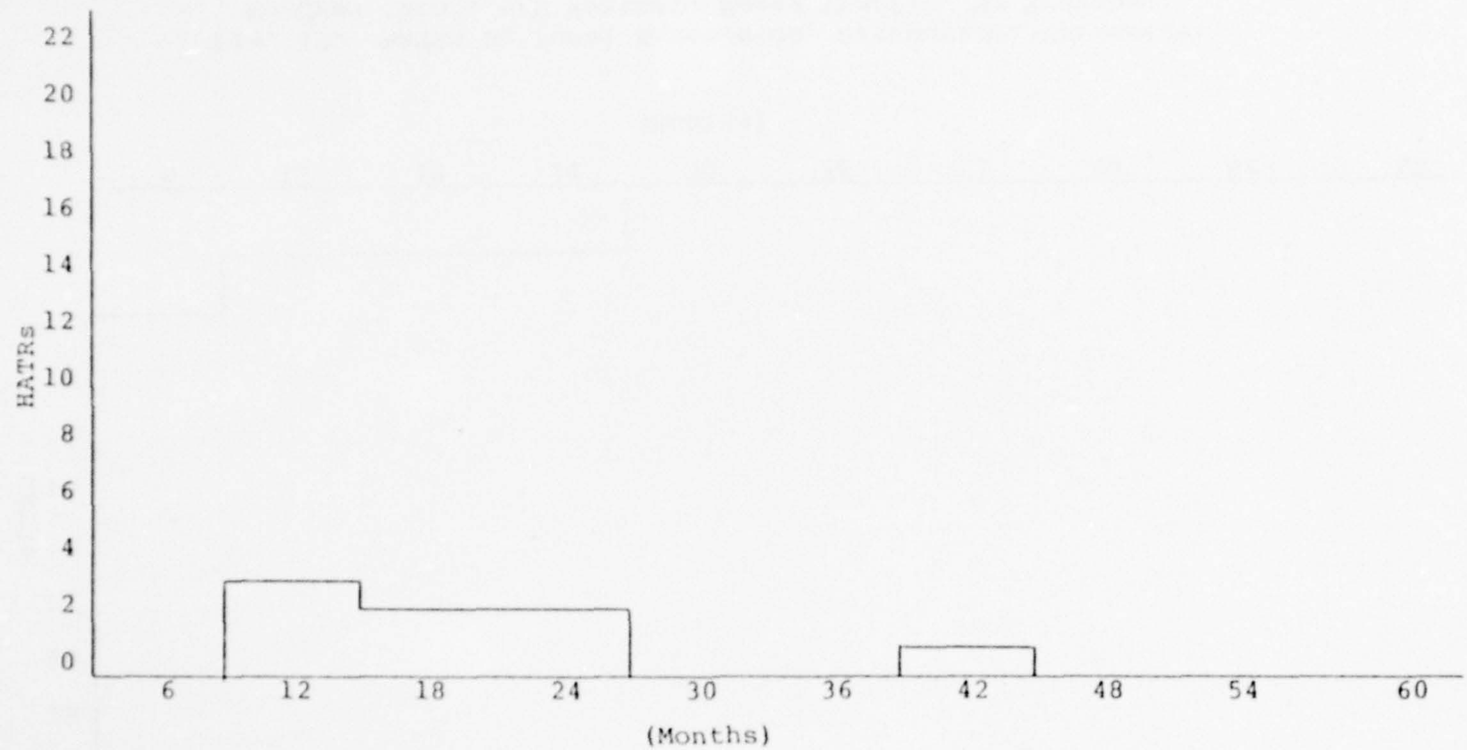

Fig. 18. HATRs By Local Experience, Categorical Variables: Crew Chief, VFR Weather, Light Traffic, No Trainee, With Equipment Failure, (8 cases)

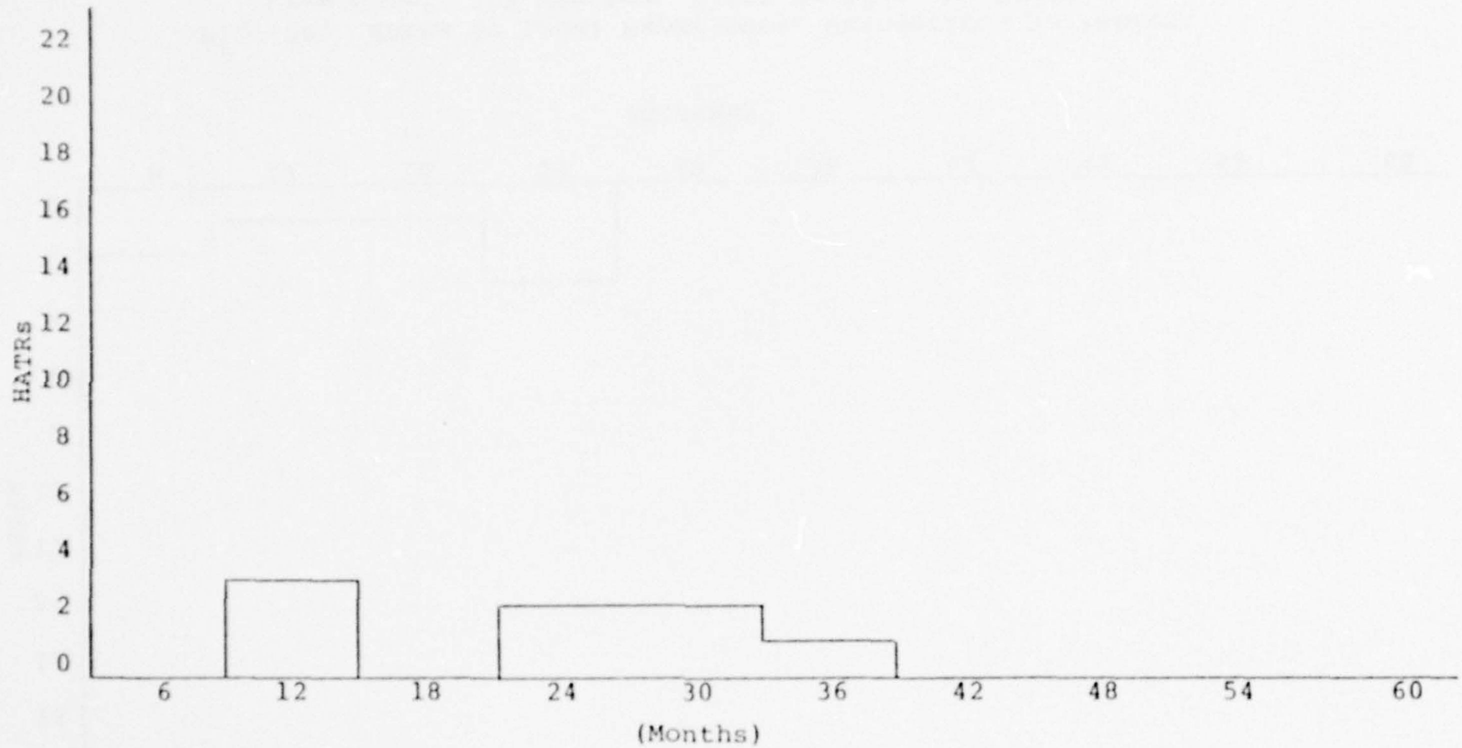

Fig. 19. HATRS By Local Experience, Categorical Variables: No Crew Chief, VFR Weather, Light Traffic, Trainee, No Equipment Failure, (8 cases)

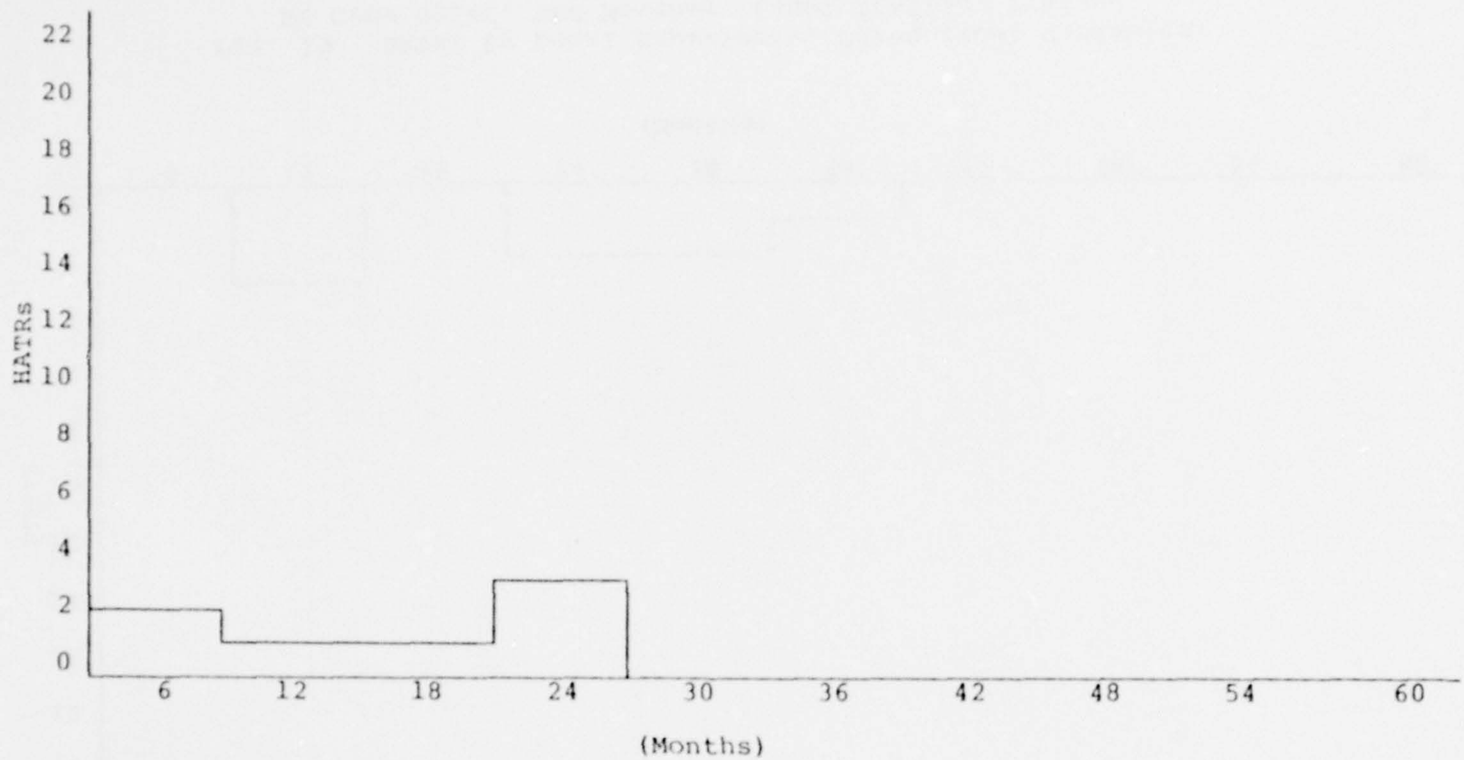

Fig. 20. HATRs By Local Experience, Categorical Variables: Crew Chief, IFR Weather, Light Traffic, No Trainee, No Equipment Failure, (7 cases)

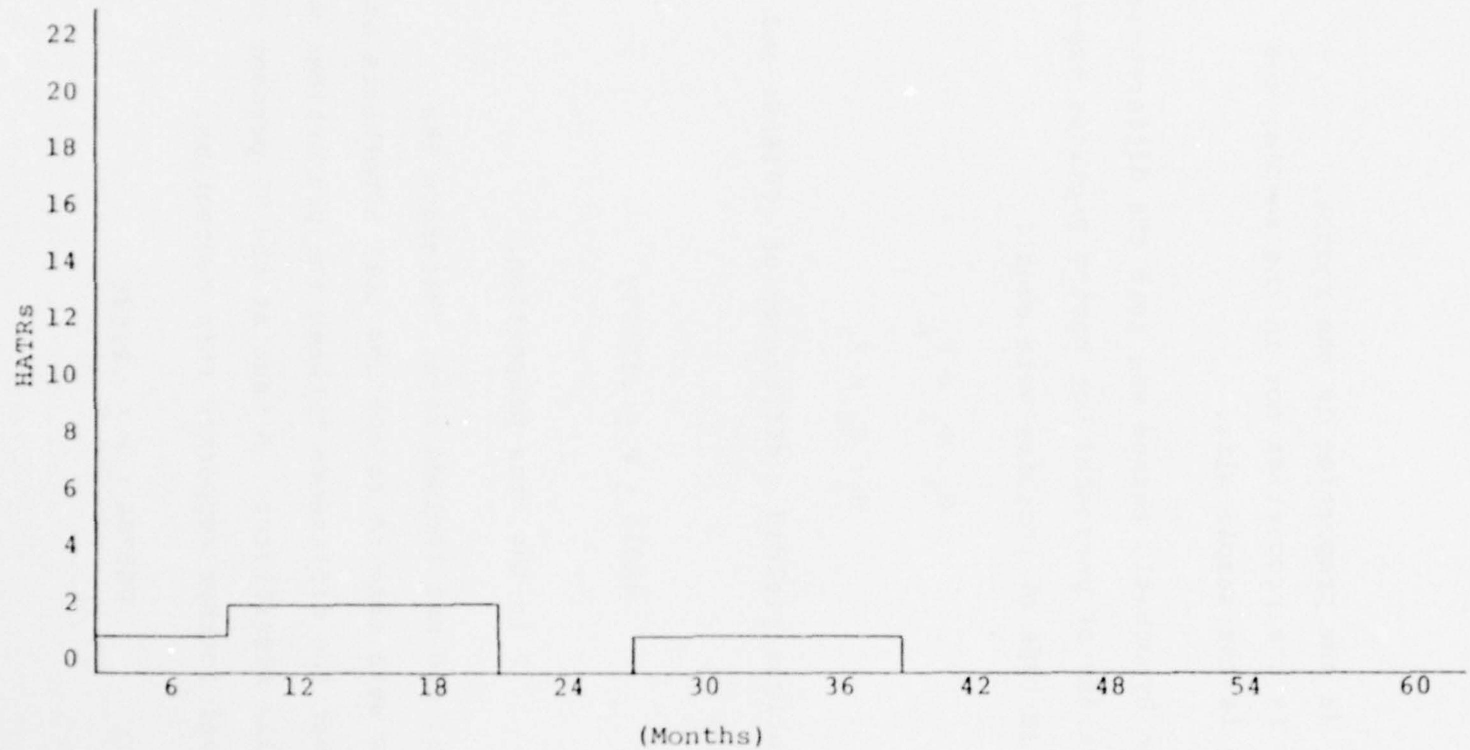

Fig. 21. HATRs By Local Experience, Categorical Variables: Crew Chief, VFR Weather, Heavy Traffic, No Trainee, With Equipment Failure, (7 cases)

where:

P_i is the proportion in the sample,

$(1-P_i)$ is the proportion not in the sample, and

n is the sample size.

The hypothesis tested was that the differences in the proportions of personnel not having previous experience in that type of facility were equal.

$$H_0: P_1 = P_2$$

$$H_1: P_1 \neq P_2$$

The computations yielded a difference of .095626, and an interval of:

$$.02015 \leq P \leq .171973$$

where: P is the true proportion.

The interval did not include zero, therefore the researchers were able to reject the null hypothesis and conclude that the difference between the proportions was statistically significant. A test at the 95 percent confidence level further supported this contention.

$$.005706 \leq P \leq .85546$$

Though the interval did not contain zero, the difference was such that a confidence level of between 90 and 95 percent was supportable. Therefore, the two proportions of controllers are different, with the cause factor controllers having a significantly smaller proportion of personnel with previous experience in that type of facility.

A review of individuals whose experience levels indicated that they were on their first tour as controllers, i.e., total experience equal to local experience, indicated that 33.497 percent of the cause factor controllers were on their first tour while 27.24 percent of the noncause factor controllers were on their first tour. A test on the difference in proportion of the two samples indicated:

$$.007372 \leq P \leq .1325123$$

at a 90 percent confidence level. Therefore, we were able to reject the null hypothesis $P_1 = P_2$, and conclude that there was a significant difference in the proportions of first tour individuals between the two samples.

A review of individuals with previous tours in different types of facilities was made where total experience level was greater than the facility experience level. In the noncause group 54.1218 percent had prior

experience in other facility types and 45.3202 percent of the cause factor controllers met this criteria.

Again, a test of the differences of the proportions was conducted at the 90 percent confidence level. The interval developed was:

$$.01244 \leq P \leq .1635906$$

Therefore, H_0 was rejected and we concluded that the differences between the two proportions was statistically significant. The noncause factor group had a significantly larger proportion of personnel with prior experience than the cause factor group.

Two additional tests of proportions were conducted. The first was to compare the proportions of personnel with the less than two years local experience between the two groups. The cause factor group had a significantly higher percentage of individuals (78.32 percent) than the non-cause factor group (54.48 percent). The test of the differences of proportions resulted in the following interval, at a 90 percent CI:

$$.1968632 \leq P \leq .2799368$$

As the interval of the difference in proportions does not contain the value zero, the hypothesis, $P_1 = P_2$ is rejected.

The last test was on the proportions of personnel with over four years total experience between the groups. The cause factor group had 42.88 percent of its personnel with over four years total experience while the non-cause factor group had 48.03 percent. The test, again at the 90 percent CI, resulted in the following interval:

$$-.0271813 \leq P \leq .1511813$$

The null hypothesis, that the proportions are equal, could not be rejected. There was no significant difference between the proportions of total experience (over four years), between the two groups.

Multiple Linear Regression

Multiple linear regression is used when attempting to identify a relationship between a dependent variable and numerous independent variables. Our second objective was to identify whether or not a statistically significant relationship existed between the number of filed HATRs and the experience levels of the air traffic controllers involved, recognizing that numerous situational factors also bear on the incident creating the HATR. A strong regression would show a high degree of correlation between the number of HATRs and the experience levels thereby supporting the hypothesis that there is a relationship.

H_0: There is no significant relationship between the number of HATRs and an ATC controller's experience level.

H_1: There is a significant relationship between the number of HATRs and an ATC controler's experience level.

A number of regressions were performed using various combinations of experience and the categorical variables. All proved futile, as none of the computed F statistic exceeded F critical, and the largest R^2 did not exceed 4 percent.

Our first regression consisted of only three independent variables (total experience, facility experience, and local experience) and the dependent variable, number of HATRs in the interval. First we divided the data base into nineteen, two-month intervals, summed the number of HATRs during the period for the dependent variable, and averaged each of the variables for each period. The resultant regression:

$$\hat{Y} = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + e_i$$

had an F statistic of .192. F_{16}^{3} critical was 3.24 at a 95 percent confidence level, and 1.51 at 75 percent.

The next step was to redivide the data base into thirty-eight, one-month periods and again find the averages for each variable for each period. A regression of the three experience levels was again performed against the number of HATRs. The computed F statistic was .32921, and F^{4}_{34} critical was 2.88 at 95 percent confidence, and 1.41 at 75 percent.

The next regression included all variables, continuous and categorical alike, on the entire 203 records in the data file. Again, the regression failed to show any correlation of reasonable significance. The computer was unable to compute the value for F due to a very low tolerance level and no analysis could be performed on the regression.

Lastly, we attempted to regress the presence/absence of a crew chief, the weather, traffic density, the presence/absence of a trainee, and equipment failure, against local experience. The regression was very weak and the computed F statistic was .494. The F^{5}_{193} critical was 2.21.

The variance of y, the number of HATRs, is not very well explained by any of the individual regressors: the experience level of the controller, the presence/absence of a crew chief, whether or not the traffic was light or heavy, whether or not the weather was IFR or VFR, whether or not a trainee was involved, whether or not

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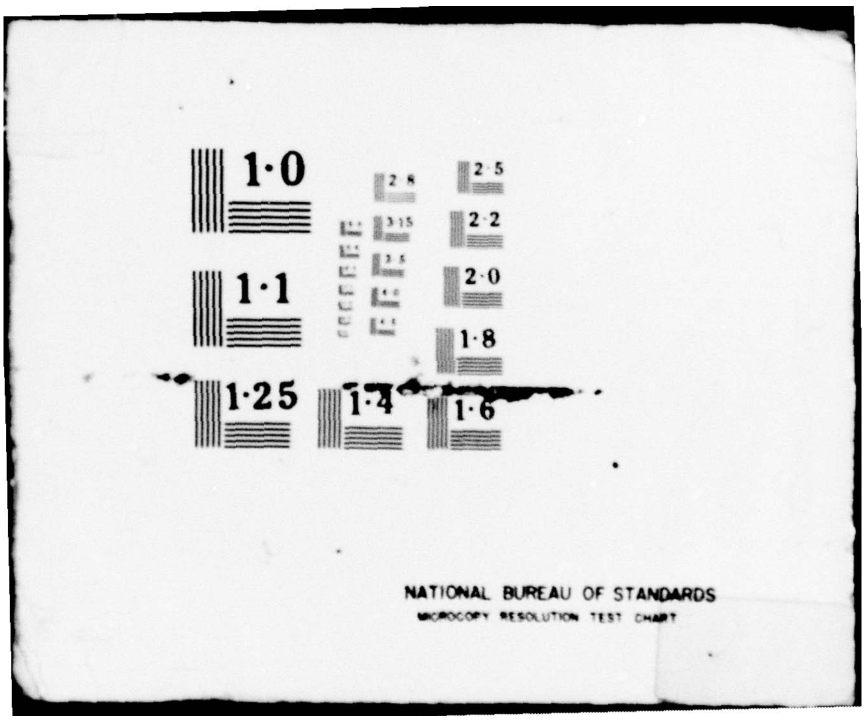
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MICROCOPY RESOLUTION TEST CHART

there was an equipment failure. Autocorrelation did not appear as a problem in any of the regressions the researchers ran, but a significant degree of multicollinearity (77 percent) did exist between total experience and facility experience. The salient fact pervading each of our attempts to use the multiple regression to fit a line to the data was that very little of the variance was explained, thereby making it impossible to show correlation at any appreciable level of significance.

Test of Means and Differences

Our last objective was to find out whether or not there was a statistically significant difference with the experience levels and the situational variables of controllers cited as the cause of a HATR, and the experience levels of controllers and situational variables in HATR's caused by pilots, material fatigue, etc. To accomplish this objective a twelve month random sample of HATRs was drawn from each of the above populations. The sample means, standard deviations, and variances for each factor was then computed, and these are listed in Tables 9 and 10. A Student's t-test was performed on the means using the Behrens-Fischer approximation to compute the degrees of freedom due to the unequal variances. The hypothesis was that the means were equal:

TABLE 8

CONTROLLER CAUSE FACTORS

	$\bar{X}$	S	S^2
X_T	61.212766	61.159782	3660.9335
X_F	33.93617	24.722287	598.18742
X_L	18.510638	12.949521	164.12223
CC	.8297872	.3798826	.1412404
W_X	.8297872	.3798826	.1412404
TFC	.5319149	.5043749	.2489814
TNG	.212766	.4136881	.1674966
EQ	.0638298	.2470922	.0597555
EM	.0212766	.145865	.0208239

TABLE 9

NON-CONTROLLER CAUSED HATRs

	$\bar{X}$	S	S_2
X_t	56.176471	52.866892	2740.1061
X_F	40.392157	35.235254	1217.1795
X_L	24.627451	15.161742	225.37101
CC	.8431373	.367209	.1322568
W_X	.8627451	.3475404	.118416
TFC	.4509804	.5025426	.2475971
TNG	.1176471	.3253957	.1038062
EQ	.0980392	.3003266	.0884275
EM	.0392157	.1960392	.0376778

$$H_0: \quad \mu_1 = \mu_2$$

$$H_1: \quad \mu_1 = \mu_2$$

The test statistic was:

$$(\mu_1 - \mu_2) = (\bar{X}_1 - \bar{X}_2) \pm t_{.025}\sqrt{\frac{\sigma_1^2}{n_1} + \frac{\sigma_1^2}{n_2}}$$

and the Behrens-Fischer approximation for the degrees of freedom:

$$df = \frac{\left(\frac{S_1^2}{n_1} + \frac{S_2^2}{n_2}\right)^2}{\frac{\left(\frac{S_1^2}{n_1}\right)^2}{n_1 - 1} + \frac{\left(\frac{S_2^2}{n_2}\right)^2}{n_2 - 1}}$$

The results were (95 percent confidence intervals).

For total experience:

$$5.036295 \pm 22.8304$$

For facility experience:

$$- 6.455987 \pm 12.088046$$

For local experience:

$$- 6.116813 \pm 5.5971741$$

Crew Chief:

$- .0133501 \pm .1488966$

Weather:

$.0329597 \pm .1452427$

Traffic:

$.9828953 \pm .2005098$

Trainee:

$.0951189 \pm .1489069$

Equipment:

$- .0342094 \pm .1090924$

Emergency:

$- .0179391 \pm .068412$

Note that in each case, with the exception of local experience and traffic density we were unable to reject the null hypothesis.

The Students t-test on the means of the the sub-populations is based on the assumption that the variances are equal. Therefore, an F-test was accomplished at the 95 percent level of confidence on the variances of the

comparable subpopulations. The hypothesis was that the variances were equal:

$$H_0: \quad \sigma_1^2 = \sigma_2^2$$

$$H_1: \quad \sigma_1^2 \neq \sigma_2^2$$

The results were:

Total Experience:	3660.9335/2740.1061 = 1.3360554
Facility Experience:	1217.1795/598.18742 = 2.0347795
Local Experience:	225.37101/164.12223 = 1.37319
Crew Chief:	.1412404/.1322568 = 1.0679254
Weather:	.8627451/.8297872 = 1.0397185
Traffic:	.5319149/.4509804 = 1.1794635
Training:	.212766/.1176471 = 1.8085104
Equipment Status:	.0980392/.0638298 = 1.5359472
Declared Emergency:	.0392157/.0212766 = 1.8431375

The F critical statistic for the above analysis was 1.54. Facility experience, training and emergencies clearly exceed the F critical value. The equipment status was questionable as it was so close to the F critical

value. In the case of total experience, local experience, crew chief, weather, and traffic, we could not reject the hypothesis that the variances were equal. Therefore, the t-tests on the means of local experience and traffic density were valid, and statistically significant differences existed between these populations.

One second series of tests on this obejctive is on HATRFIL, the HATR file consisting of 482 records containing 203 controllers cited as the cause of the filed HATR, and 279 controllers on duty at the time of the HATR, but not cited as the cause. Our first question to be addressed here was: Is there any statistically significant difference between the experience levels of those controllers cited as cause, and those not cited as cause? The hypothesis is that the means of the two populations are equal:

$$H_0: \mu_1 = \mu_2$$

$$H_1: \mu_1 \neq \mu_2$$

Where

μ_1 = the means of the controllers experience (total, facility, and local) cited as cause.

μ_2 = the mean of the controllers experience (total, facility, and local) cited as non-cause.

Using the statistical data contained in Table 3, an F-test of the variances was first performed to validate the use of the Student's t-test. The hypothesis was:

$$H_0: \quad \sigma_1^2 = \sigma_2^2$$

$$H_1: \quad \sigma_1^2 \neq \sigma_2^2$$

where:

σ_1^2 = the variances of the controllers experiences cited as cause, and

σ_2^2 = the variances of the controllers experiences cited as non-cause

The results were:

Total Experience: 3,224.19552/2,275.6716 = 1.4168

$$F_{C_{202}}^{278} = 1$$

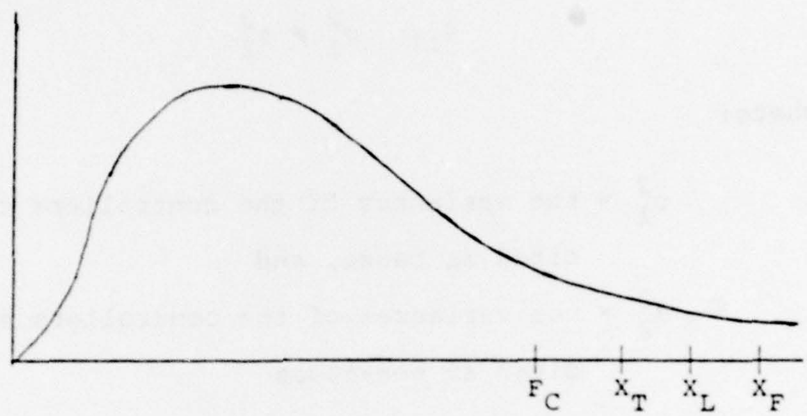
Facility Experience: 1,850.729/927.2695 = 1.9959

$$F_{C_{202}}^{278} = 1$$

Local Experience: 334.7436/175.6924 = 1.8053

$$F_{C_{202}}^{278} = 1$$

Pictorally, this is represented as:



Since each computed F statistic exceeded F critical the hypothesis that the variances were equal was rejected. Therefore, the Behrens-Fischer approximation for unequal variances was used to compute the degrees of freedom for the t-test. This validates the t-test of the means. Using the test statistic:

$$(\mu_1-\mu_2) = (\bar{X}_1-\bar{X}_2) \pm t_{.025}\sqrt{\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}}$$

and the Behrens-Fischer approximation for the degrees of freedom:

$$df \approx \frac{\left(\frac{s_1^2}{n_1}\right) + \left(\frac{s_2^2}{n_2}\right)}{\frac{\left(\frac{s_1^2}{n_1}\right)^2}{n_1 - 1} + \frac{\left(\frac{s_2^2}{n_1}\right)^2}{n_2 - 1}}$$

For total experience (95 percent CI):

$$54.35 - 66.5 \pm 1.96 * 4.7613$$

$$-12.15 \pm 9.3321$$

For facility experience (95 percent CI):

$$36.36 - 45.33 \pm 1.96 * 3.3399$$

$$-8.97 \pm 6.5462$$

For local experience (95 percent CI):

$$17.79 - 21.018 \pm 1.96 * 1.4341$$

$$-3.228 \pm 2.8109$$

In each case, the researchers rejected H_0. The mean experience level of the controllers cited as cause factors was statistically different from the mean

experience levels of those controllers listed in the HATR but not cited as cause.

Having looked at the facts derived from the descriptive and inferential statistics used in the analysis of the trends in experience levels, the linear regression, and the tests of the various individual populations, we next developed our conclusions and formulated our recommendations. These conclusions and recommendations are set forth in the next and final chapter, Chapter V.

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

This chapter is divided into two sections: The first section contains the conclusions drawn as a result of our research, and the second section contains our recommendations. The first section is further subdivided into three parts, one for each of our research objectives. The results of our analysis are catalogued and presented by objective. Our recommendations are divided into two parts. The first contains our recommendations to AFCS for possible policy changes and management action, and the second contains our recommendations for areas of further related study.

Under objective one, trend analysis, we had four major areas of research: trend lines and characteristics, the distribution of HATRs by experience levels, the categorical variables, and the proportions. Though descriptive rather than inferential, this analysis was useful in describing the nature of the experience levels and the categorical variables surrounding the occurrence of the HATR. The specific findings were as follows:

1. Controller-caused HATRs have decreased at a statistically significant rate over the period of analysis.

2. The local experience level of the controllers cited as non-cause factors increased at a statistically significant rate.

3. The experience levels of all controllers cited as cause factors failed to demonstrate any significant trends.

4. See Table 10

TABLE 10

PERCENTAGE OF CONTROLLERS WITH UNDER FOUR, AND UNDER SIX, YEARS EXPERIENCE

Experience	All Controllers	"Cause" Controllers	"Non-Cause" Controllers
Total			
Under 4 Years	54.36%	58.12%	51.97%
Under 6 Years	70.33	76.84	65.94
Facility			
Under 4 Years	67.1	73.39	62.36
Under 6 Years	82.36	39.16	76.70
Local			
Under 4 Years	87.75	98.0	79.92
Under 6 Years	92.73	99.0	87.45

5. When considering the sample of all controllers identified, both cause and non-cause, controllers with two years or less experience make up 64.73 percent of the population, and accounted for 78.43 percent of the HATRs by local experience. When the proportions of the two samples were compared, a significantly higher number of controllers with zero to twenty-four months local experience was found in the cause factor group.

6. Of the controllers cited as cause factors in the HATRs, over 98 percent had four or less years experience at the local facility, 73.39 percent had four or less years experience in the same type facility, and 58.12 percent had four or less years total experience.

7. The situational variables affecting the HATRs occurred as follows in the 199 cases cited as controller caused: (The percentage of controllers with two or less years local experience is included in parentheses).

a. Crew chief on duty, 70.35 (79.28) percent.

b. VFR Weather 87.43 (77.58) percent.

c. Light Traffic, 56.78 (79.14) percent.

d. Trainee in Position, 20.1 (72.5) percent.

e. Equipment Failure, 11.55 (86.95) percent.

When the data in the situational combinations (Figures 12 to 21) was replotted by total experience, rather than

local experience, the histograms became random in nature and displayed no identifiable patterns.

8. Controllers on their first tour of duty make up 27.24 percent of the non-cause group and 33.5 percent of the cause factor group. When tested at a 90 percent confidence level this difference in proportions was statistically significant.

9. Controllers with previous experience in a facility of the type in which the HATR occurred made up 53.4 percent of the non-cause group and 43.84 percent of the cause factor group. Again, this difference between the two samples is statistically significant.

10. Controllers with previous experience in other types of facilities comprised 54.12 percent of the non-cause group while 45.32 percent of the cause factor group had previous experience in other facilities. This difference in proportions was also statistically significant.

11. Controllers in the zero to twenty-four month local experience zone, regardless of total or facility experience, have the highest HATR rate of any group. The proportions of individuals with total experience over four years was not significantly different between the cause and non-cause group.

The sample of non-cause factor controllers was used to confirm the declining experience levels of ATC controllers as reported by AFCS. Care must be taken

though to recognize that while AFCS reported a decline in the median experience level we, of necessity, measured the mean of the sample over time. The resulting least squares line, while positive in nature, was not statistically significant. There were thirty-four very high time individuals in the sample (over 132 months total experience). In order to insure that the actual trend was not being masked by these high time individuals, they were removed from the sample and the trend line recomputed. Again a slightly positive (0.045X) slope was identified, but it too proved to be statistically insignificant. In conclusion, though the median experience level had decreased by 20 percent, the mean of the sample of non-cause controllers does not reflect this decline.

Throughout the descriptive statistics the zero to twenty-four months time period for local experience persisted in surfacing again and again. When the HATRs were plotted by the five situational variables (weather, traffic, etc.) in combinations, we found the percentages of personnel in the zero to twenth-four month area range from 100 percent (highest) to 61.5 percent (lowest), and accounted for 78.53 percent of the occurrences. As pointed out in seven above, the personnel identified in the zero to twenty-four month range made up over 70 percent of the population in each instance. Further, when the proportions in the zero to twenty-four month group

were examined, it was found that 78.32 percent of the cause factor group and 54.83 percent of the non-cause group fell in this experience level.

The significance of the period from zero to twenty-four months local experience may result from any single or combination of the following factors: (1) The period zero to twenty-four months local experience is one of high vulnerability for HATRs. (2) The majority of the personnel in the zero to twenty-four months are the "front line" controllers. (3) The majority of the controllers have less than twenty-four months experience. Evidence indicates that three, above, may be rejected. This leaves one and two which, in combination, may indicate that a relationship exists between local experience and quality of service as measured by the Hazardous Air Traffic Reports.

Our second objective was to determine if a statistically significant relationship existed between the number of reported hazards and the total, facility, and local experience levels of the controllers involved, and the situational factors (weather, crew chief, traffic, trainee, equipment failure) bearing on the situation.

The multiple linear regressions attempted with various combinations of the variables proved inconclusive. Every attempt to regress the experience levels to the number of HATRs failed to produce a significant

regression. The authors can only speculate as to why a valid regression could not be accomplished. Possible reasons are the distribution and/or frequency of the HATR occurrence, the lack of the predictive power of the variables, or the point that the wrong variables are being looked at. However, it is apparent that, given the data contained in the HATR as it was operationally defined, no significant association could be identified between the occurrences of HATRs and the total, facility, or local experience levels of the ATC controllers cited as cause. Also, no significant level of association could be identified between the occurrence of a HATR or local experience and the nominal factors such as the presence/absence of a crew chief, the traffic density (light, or moderate to heavy), the weather conditions (IFR or VFR), the presence/absence of a trainee, and equipment failure.

The analysis in support of objective number two, the multiple linear regression, proved inconclusive. The regression as designed was incapable of fully describing the HATR due to either the ineffectiveness, or the insufficiency of the variables. While the reduced mean experience levels of the controllers as reported by AFCS may be causing an increase in training, processing, and recruitment costs, this analysis cannot support that contention.

The third objective was to determine whether or not a statistically significant difference exists between

the experience levels of controllers and the distribution of situational variables as cause factors and those identified but not cited as cause of the HATR.

A test of the differences between the means of the samples of cause and non-cause factor controllers revealed (at a 95 percent CI) that all three levels (total, facility, and local) were significantly lower for the cause factor group. From this, one may infer that the population from which the sample of cause factor controllers was drawn is statistically less experienced that the non-cause factor population. Therefore, it can be stated with 95 percent confidence that controllers receiving HATRs have less experience on the average than controllers not receiving HATRs.

A twelve month random time interval was identified and the HATRs occurring within the period were divided into two samples: controller caused HATRs and those attributed to other causes, i.e., pilot, material, etc. The controller caused sample contained forty-seven data records and the non-controller caused sample contained fifty-one records. The samples were compared as to experience levels and the occurrence of situational variables. The differences were statistically significant when local experience and traffic were considered. All other variables failed to reject the null hypothesis, that the means of the samples were equal. Therefore, light

traffic was a factor in more controller caused HATRs than in HATRs caused by other factors, and the local experience levels of the cause factor controllers were lower than the local experience levels of controllers identified in HATRs caused by pilots, etc. This was consistent with two earlier findings that the mean of the local experience levels of the cause factor group of controllers is lower than that of the non-cause factor group. Therefore, we are able to conclude with a confidence level of 95 percent that a significant relationship exists between local experience levels of air traffic controllers, particularly at the two year or less level, and the quality of service as measured by Hazardous Air Traffic Reports.

As a result of the above conclusions, the following recommendations are offered for management consideration and for areas of further research.

Recommendations

The following actions are recommended for management consideration. Since local experience (particularly the first twenty-four months of a controller's tenure at a base) appears to be a major factor in the occurrence of a HATR, we believe that increased managerial emphasis should be placed on an air traffic controller's first two years on station, and that a survey be initiated in an attempt to define problem areas affecting retention. The rationale

for this latter recommendation is the fact that the high turnover rate of personnel in the 272XO career field drives, of necessity, a high turnover rate of line controllers in the field. In other words, the high turnover rate forces more people through the zero to twenty-four month time interval than would occur if the force were more stable.

Though unable to validate the declining experience level, this research demonstrated a significant relationship between the quality of service as measured by HATRs and the first two years of local experience regardless of total experience. In an effort to improve the quality of service of this group, the authors submit the following recommendations.

First, supervisory emphasis should continue at an increased level even after the controller has been rated until he has a minimum of twenty-four months on station. Second, increased emphasis should be placed on mangerial and supervisory evaluations. The CATCO, chief controller, or a supervisor who normally does not work with the new (zero to twenty-four month local experience) controller should increase their number of spot or no-notice "over-the-shoulder" evaluations on a controller after he is certified. This would tend to reduce any complacency that could develop in a controller after he realizes that he is

a rated, "fullfledged" controller, but before he has been exposed to a greater number of air traffic problems.

Thirdly, increased emphasis should be placed on crew integrity (the same controllers working with each other over a period of time). The rationale behind this recommendation is that the men on the crew work as a team and the team functions better when each member of the team knows the other members. The full effect of crew integrity is not known and constitutes a major portion of a recommendation for further study.

Another method of reducing the number of controllers in the zero to twenty-four month local experience level of controllers is to reduce the number of intrafacility transfers . . . the number of times a controller is moved between facilities and therefore re-enters the zero to twenty-four month local experience zone. We recognize that manning requirements may preclude this; however, a concerted effort in this area should be stressed. Lastly, and in parallel with our fourth recommendation, the number of Permanent Change of Station (PCS) assignments should be reduced to the maximum extent possible. This, too, would reduce the number of times a controller enters that zero to twenty-four month local experience level, thereby permitting him to gain greater knowledge and experience about the local air traffic area and the operational customers he serves. One must recognize, however, that any increase

in stability may be accompanied by a loss in managerial flexability and may not, when all variables are accounted for, result in an optimal solution.

Along with the above-stated recommendations for possible management action and policy changes, we recommend the following areas for further study and analysis.

The first recommendation deals with a reduction of the number of personnel falling in the zero to twenty-four month local experience group. We believe a study should be initiated to identify specific alternatives that would result in a more stable work force. The benefits of a more stable work force are fewer personnel transfers into the more vulnerable zero to twenty-four month local experience group, increased quality of service, and lower personnel costs due to fewer PCS moves.

The second recommendation deals with the effectiveness and efficiency of measures of the quality of air traffic control services. Our research demonstrated that a significant relationship exists between the local experience levels of air traffic controllers and the quality of service as measured by Hazardous Air Traffic Reports. However, the specific strength and nature of the relationship could not be identified from the existing data. Therefore, new measures should be devised to provide management with tools to not only measure the effectiveness of its controller force but also provide a basis

from which to measure the impact of policy changes on the quality of service as related to experience levels.

The third recommendation is that AFCS undertake a study of the job environment of the controllers in an attempt to access the impact of factors such as crew integrity, shift length, rotation schedules, specific job assignments, the degree of job satisfaction and, the effect of the geographical location on the quality of service. These variables were not considered in this study and their omission may have attributed to the inconclusive regression.

The final recommendation is that AFCS coordinate with the Air Traffic Services Branch of the Federal Aviation Administration in an attempt to have the FAA review their systems deviations (a measure of quality of services similar to the HATR) to determine if the same vulnerable zero to twenty-four month period exists within their work force. It is recognized that, with the much more stable work force, the relationships may not be as intense as with the highly mobile USAF controllers yet due to a much greater number of facilities and controllers, it may still be identifiable.

In conclusion, while we have not been able to support a declining experience level or an attendant increase in the number of HATRs, based on our sample we have been able to demonstrate that the local experience

level of the non-cause factor controllers is increasing and that the controller caused HATR rate has decreased. Furthermore, we have identified a subpopulation of controllers that appears to have a significantly higher vulnerability to HATRs than the remainder of the population regardless of total experience. That subpopulation is characterized by a local experience level of from zero to twenty-four months.

In this thesis we have attempted to identify the effort of experience levels on the quality of ATC services. Our study has identified a need for stability in the work force that may be enhanced by an increased retention rate. Though an increase in retention would result in an increase in stability, the costs associated with it are unknown. Therefore, a cost/benefit analysis should be undertaken to insure that the benefits to be gained are not exceeded by the costs incurred prior to any managment action.

APPENDIXES

APPENDIX A

HOUTKOOPER DESCRIPTION STATISTICS

This statistical trend analysis concerns the experience level of AFCS air traffic control (ATC) personnel involved in hazardous air traffic reports (HATRs) submitted since 1 Jan 74. Statistics furnished deal with the following factors: total ATC experience, total same type facility experience, total local experience, grade, AFSC, duty position and facility ratings. The experience levels from CY 74, CY 75, and CY 76 are compared against each other and the command skilled controller (AFSC 27250, 27270, and 27290) experience levels taken from data as of 5 Jan 76 and 3 Jan 77. Supervisory statistics have been broken out from the overall data. The CY 74, CY 75, and CY 76 supervisory experience levels have also been compared against each other and the command experience level of 27270 and 27290 personnel. Trainee controllers are not included in this study.

Source documentation was taken from the Accident/Incident File Summary, a computerized data base containing HATRs submitted IAW AFB 127-3. Source documentation for command experience level data is the Personnel Computer Listing (SPIRES) as of 5 Jan 76 and 3 Jan 77. Calculations for HATRs are based on information submitted by the AFCS unit involved in each occurrence.

Of the 110 HATRs submitted during CY 74, 81 involved valid complaints against air traffic controllers and 99 personnel, including 19 supervisors, were cited as contributing factors. In CY 75, 75 of the 129 HATRs submitted cited 102 controllers, including 11 supervisors, as contributing factors. This compares to 62 of the 154 HATRs filed during CY 76, which cited 105 controllers, including 21 supervisors, as contributing factors.

The following is a list of experience level means for all supervisors/controllers involved in HATRs during CY 74, CY 75, and CY 76 as compared to command skilled controller experience level.

Total Exper	CY 74	CY 75	5 Jan 76 Skilled Controller	CY 76	3 Jan 77 Skilled Controller
ATC	5.96 yrs	5.52 yrs	7.19 yrs	5.00 yrs	6.80 yrs
Facility	3.99 yrs	4.12 yrs	NA	3.28 yrs	NA
Local	1.68 yrs	1.59 yrs	1.81 yrs	1.85 yrs	1.89 yrs

NOTE: The total facility experience mean could not be computed from the SPIRES data so no comparison can be made.

The data listed above portrays a continuing decrease in the total ATC experience level of controllers involved in HATRs, which parallels the decreasing command skilled controller experience level. The experience level in similar type facilities showed a significant decrease during CY 76, as compared to a slight increase for CY 75 over CY 74. The experience level at the present unit of assignment increased slightly during CY 76 and is just slightly lower than the command skilled controller mean for local experience.

The following is a list of experience level means for supervisors involved in HATRs during CY 74, CY 75, and CY 76 as compared to command supervisory (27270 and 27290) experience levels.

Total Exper	CY 74	CY 75	5 Jan 76 Supvr Controller	CY 76	3 Jan 77 Supvr Controller
ATC	8.37 yrs	7.09 yrs	10.30 yrs	9.40 yrs	10.99 yrs
Facility	5.00 yrs	5.53 yrs	NA	6.10 yrs	NA
Local	2.21 yrs	2.26 yrs	2.12 yrs	3.29 yrs	2.24 yrs

The signficant fluctuations in total ATC experience of supervisors was caused by the number of personnel with more than 10 years experience cited in the data; six during CY 74, three during CY 75, and 10 during CY 76. Almost half of the supervisors identified during CY 76 were in this category. The supervisory (27270/27290) ATC experience level increase between 5 Jan 76 and 3 Jan 77 is a result of a reduction in the supervisory force from 2700 to 2300. The majority of these losses were in the lower end of the spectrum, i.e., second and third term controllers. The continued increase in same type facility experience was due to the number of supervisors with more than five years experience; eight in CY 74, five in CY 75, as compared to 14 in CY 76. The same holds true for local experience as the number of supervisors identified with more than three years local experience has fluctuated; from six in CY 74, three in CY 75, as compared to nine in CY 76.

The grade of controllers involved in HATRs has remained fairly constant in their rates of occurrence in CY 76 as compared to CY 74 and CY 75. The number of E-3s appearing in the data has been increasing since CY 74 and is one of the prime factors bringing the experience level down.

Another prime factor is the number of cross-trainees entering the career field. Three out of 12 E-7s and four out of 20 E-6s, all with experience levels well below that of other controllers identified in the HATR data, were noted.

The rate of occurrence by skill levels also remained fairly constant. The following is a list of total ATC experience level means for controllers involved in HATRs during CY 76 as compared to the command mean experience levels for each AFSC.

	Total ATC Experience	
AFSC	HATR	COMMAND
27250	2.13 years	2.40 years
27270	7.06 years	9.54 years
27290	15.25 years	18.79 years
16XX	2.00 years	6.54 years

NOTE: AFSC 1631 is not included in the command 16XX experience level. As shown above, the ATC experience of controllers involved in HATRS is less than the command experience level for all AFSCs. The small size of the 27290 and 16XX samples, four and three individuals respectively, should be considered in noting the large difference in total ATC experience.

The following data are listed for comparison.

NOTE: Figures in parenthesis indicate supervisory personnel included in the cited figure. Total ATC experience and total facility experience data were not available for one supervisor during CY 76 due to PCS before the HATR was processed. Complete information was not available for some of the HATRs submitted during CY 74.

Total ATC Experience (years)

	CY 74	CY 75	CY 76
Less than 1	7	15	13
1-2	10(1)	7	13
2-3	16(1)	14(1)	7
3-4	15(1)	10(2)	10(2)
4-5	6(1)	13(2)	11(1)
5-6	12(3)	12(1)	9(4)

	CY 74	CY 75	CY 76
6-7	6	4(1)	7(2)
7-8	8(4)	4	4
8-9	2(1)	3(1)	8(1)
9-10	1(1)	3	2
10-11	5(3)	2(1)	1(1)
11-12	3(1)	1(1)	1(1)
12-13	0	3	4(4)
13-14	0	2(1)	1(1)
14-15	0	4	2(2)
15-16	1(1)	0	2(1)
16-17	1	0	0
17-18	2	0	1
18-19	1(1)	1	0
19-20	0	1	0
20-21	1	2	0
21-22	0	0	0
22-23	1	0	0
23-29	0	0	0
29-30	1	0	0

Total Same Type Facility Experience (years)

	CY 74	CY 75	CY 76
Less than 1	15(1)	17	24(2)
1-2	14(2)	14(1)	24
2-3	22(3)	16(4)	13
3-4	12(1)	14(1)	10(2)
4-5	6	9(1)	7(2)
5-6	8(3)	9(1)	10(6)
6-7	4	6(1)	6(4)
7-8	3(3)	5(1)	3(1)
8-9	2(2)	0	2
9-10	0	2	2(1)
10-11	5(2)	3	0
11-12	1	0	1(1)
12-13	0	2(1)	1(1)
13-14	1	0	0
14-15	0	1	1
15-16	1	0	0
16-17	1	0	0
17-18	0	0	0
18-19	1	1	0
19-20	0	0	0
20-21	0	1	0

Total Local Experience (years)

	CY 74	CY 75	CY 76
Less than 1	38(7)	45(3)	34(4)
1-2	24(4)	27(2)	36(3)
2-3	18(2)	14(3)	18(5)
3-4	11(3)	11(2)	9(2)
4-5	3(2)	4(1)	2(1)
5-6	0	1	4(4)
6-7	1(1)	0	1(1)
7-8	0	0	1(1)

Grade

	CY 74	CY 75	CY 76
E-2	0	4	4
E-3	7	15	18
E-4	19	28	20
E-5	42(9)	27(5)	26(6)
E-6	23(8)	18(6)	22(8)
E-7	5(2)	8	12(7)
E-8	0	0	0
E-9	1	0	0
0-1	0	2	0
0-2	1	0	2
0-3	1	0	1

AFSC

	CY 74	CY 75	CY 76
27250	37	50	47
27270	59	50	51
27290	1	0	4
16XX	2	2	3

Position

	CY 74	CY 75	CY 76
ATC NCO	1	0	0
Crew Chief	16	7	16
Senior Controller	3	3	5
Approach/Departure Control	22	20	24
Arrival Control	15	11	10

	CY 74	CY 75	CY 76
Final Control	8	12	11
Coordinator	2	15	4
Local Control	28	30	22
Flight Data	4	2	9
Ground Control	1	1	4
ATRC	0	1	0

Facility Ratings

	CY 74	CY 75	CY 76
R-APC	53	43	41
RFC	10	24	32
GCA	8	19	15
CT	41	38	45
ATRC	0	1	0

APPENDIX B

AF FORM 457--HAZARD REPORT

USAF HAZARD REPORT	HAZARD REPORT NO. *(Assigned by Safety Office)*

1. HAZARD *(To be completed by individual reporting hazard)*	
TO: CHIEF OF SAFETY *(Organization and location)*	FROM: *(Optional - Name, Grade and Organization)*
TYPE-MODEL, SERIAL NUMBER, A.G.E./MATERIAL/FACILITIES/PROCEDURE OR HEALTH HAZARD INVOLVED	
DESCRIPTION OF HAZARD *(Date, Time, SUMMARY - Who, What, When, Where, How)*	
RECOMMENDATIONS *(Originator - Not Mandatory)*	

DATE RECEIVED	REVIEWING PERSON *(Typed or printed name, grade, and position or title)*	SIGNATURE	DESIGNATED OPR
DATE FORWARDED			SUSPENSE DATE

AF FORM SEP 73 457 PREVIOUS EDITION IS OBSOLETE

GPO : 1974 O - 533-739

II.	INVESTIGATION OF HAZARD	
SUMMARY OF INVESTIGATION		
RECOMMENDATIONS (*Investigator*)		
ACTION TAKEN		
DATE	TYPED OR PRINTED NAME AND GRADE OF ACTION OFFICER	SIGNATURE

APPENDIX C

AF FORM 561--HATR REPORT

HAZARDOUS AIR TRAFFIC REPORT (HATR)

(THIS FORM IS SUBJECT TO THE PRIVACY ACT OF 1974 - SEE ITEM 22 ON REVERSE)

REPORT CONTROL SYMBOL

INSTRUCTIONS

This form is to be completed by the individual initiating the report. This report is required for all reportable conditions identified in AFR 127-3. Complete all appropriate portions of the form. If pertinent data are not available, make an appropriate comment in the narrative. The safety office investigating the occurrence will complete those portions that cannot be filled in by the reporting individual. Turn in the report to the nearest USAF Safety Office or Base Operations. If circumstances make this impractical and communications permit, information may be transmitted to the safety office of the base where the hazardous condition occurred or to home station. Due to the perishability of air traffic control records, this report should be processed as soon as possible. Priority precedence is appropriate.

1. CONDITION REPORTED
☐ NMAC ☐ AIR TRAFFIC SERVICES ☐ PILOT PROCEDURES ☐ NAVIGATIONAL AIDS ☐ OTHER *(Specify)*
☐ PUBLICATIONS/DIRECTIVES ☐ COMMUNICATIONS ☐ FLIP/NOTAMS

2. DATE AND TIME OF OCCURRENCE	YEAR	MONTH	DAY	TIME *(L)*	☐ DAY ☐ NIGHT ☐ DAWN/DUSK

3. LOCATION	RADIAL AND DME	FROM *(Facility ident and airport)*	ICAO IDENT
OR	POSITION	ON *(Airport)*	ICAO IDENT

4. ALTITUDE/FL	5. ALTIMETER SETTING	6. KIAS	7. WX CONDITIONS AT FL ☐ VISUAL ☐ INSTRUMENT	8. FACILITY RECEIVING AIRBORNE REPORT AND TIME *(L)* RECEIVED

FACTUAL DATA *(Aircraft 2 is other aircraft involved)*

AIRCRAFT 1	AIRCRAFT 2
9. TYPE/MODEL/SERIES	9. TYPE/MODEL/SERIES ☐ UNKNOWN
10. IDENTIFICATION/CALL SIGN	10. CALL SIGN/DESCRIPTION ☐ UNKNOWN
11. MAJCOM, UNIT AND HOME STATION	11. MAJCOM, UNIT AND HOME STATION
12. AIRDROME OF DEPARTURE	12. AIRDROME OF DEPARTURE
13. DESTINATION AIRDROME	13. DESTINATION AIRDROME
14. FLIGHT PLAN ☐ IFR ☐ VFR ☐ DVFR ☐ SVFR ☐ NONE	14. FLIGHT PLAN ☐ IFR ☐ VFR ☐ DVFR ☐ SVFR ☐ NONE ☐ UNKNOWN
15. COURSE/HEADING/ROUTE	15. COURSE/HEADING/ROUTE

16. CONTROLLING AGENCY

NAME ☐ NONE	NAME ☐ NONE ☐ UNKNOWN
☐ USAF ☐ FAA ☐ USA ☐ USN ☐ HOST NATION ☐ OTHER ☐ GCA ☐ DEP CON ☐ ARTCC ☐ RSU ☐ GCI ☐ APP CON ☐ TOWER *(VFR)* ☐ RBS	☐ USAF ☐ FAA ☐ USA ☐ USN ☐ HOST NATION ☐ OTHER ☐ GCA ☐ DEP CON ☐ ARTCC ☐ RSU ☐ GCI ☐ APP CON ☐ TOWER *(VFR)* ☐ RBS

17. AIR TRAFFIC SERVICES

RADAR SERVICE ☐ NONE ☐ MONITOR ☐ VECTORS	RADAR SERVICE ☐ NONE ☐ MONITOR ☐ VECTORS
TRAFFIC ADVISORIES ☐ YES, TOO LATE ☐ YES, NO JOY ☐ NO	TRAFFIC ADVISORIES ☐ YES, TOO LATE ☐ YES, NO JOY ☐ NO
RADAR AUTOMATED DATA PROCESSING ☐ YES ☐ NO	RADAR AUTOMATED DATA PROCESSING ☐ YES ☐ NO

18. FLIGHT ACTIVITY *(Check all applicable)(Aircraft 2 is other aircraft involved)*

AIRCRAFT 1 2	AIRCRAFT 1 2	AIRCRAFT 1 2	AIRCRAFT 1 2
☐ ☐ TAXI	☐ ☐ CRUISE	☐ ☐ FINAL APPROACH	☐ ☐ DESCENT TO *(Alt)*
☐ ☐ TAKEOFF	☐ ☐ HOLDING	☐ ☐ LOW APPROACH	☐ ☐ CLIMB TO *(Alt)*
☐ ☐ LANDING	☐ ☐ OB ROUTE	☐ ☐ MISSED APPROACH	☐ ☐ SID *(Name)*
☐ ☐ DEPARTURE	☐ ☐ FORMATION	☐ ☐ TFC PATTERN *(VFR)*	
☐ ☐ ARRIVAL	☐ ☐ LOW ALT TRAINING ROUTE	☐ ☐ ACROBATICS	
☐ ☐ ENROUTE	☐ ☐ TACTICAL *(Refueling, ACM, etc.) (Specify)*		☐ ☐ INSTRUMENT APPROACH *(Name)*
☐ ☐ PREFLIGHT			
			☐ ACTIVITY UNKNOWN

AF FORM AUG 78 651 REPLACES PREVIOUS EDITION AND AF FORM 652, MAY 76, WHICH ARE OBSOLETE.

19. SPECIAL FACTORS INVOLVED *(Check all applicable)(Elaborate in narrative)*

- ☐ AIRCRAFT CONSPICUITY
- ☐ EMERGENCY
- ☐ WEATHER CONDITIONS
- ☐ OTHER(S) *(Specify)*
- ☐ CLOUD PROXIMITY
- ☐ FLIGHT CONDITIONS
- ☐ EQUIPMENT STATUS
- ☐ AIR TRAFFIC CONTROL PROCEDURES
- ☐ AIR TRAFFIC CONTROL VOLUME OR COMPLEXITY
- ☐ AIR TRAFFIC CONTROL FACILITY MANAGEMENT

20. NARRATIVE

21. REPORTING INDIVIDUAL ☐ PILOT ☐ AIR TRAFFIC CONTROLLER *(Enter AFSC)* ☐ OTHER *(Specify)*

NAME *(Optional)*

22. *AUTHORITY: 10 U.S.C. 8012.*

PRINCIPAL PURPOSE: **Information is used in the investigation of the reported condition and is solely for the purpose of mishap prevention and will not be the basis for disciplinary action.**

ROUTINE USES: **Used to assist in the investigation of the circumstances that developed into an alleged hazardous air traffic condition and to compile statistics on USAF hazardous experiences for analysis and determination of hazard reduction measures. Information contained on this form will be used in the NASA Aviation Safety Reporting System which utilizes deidentified data in aviation safety research. Information contained hereon may be disclosed to any USAF component and, upon request, to other DOD, Federal, State, and local agencies in the pursuit of their official duties.**

DISCLOSURE IS MANDATORY: **Failure to report hazardous conditions within the time parameters prescribed for the NASA Aviation Safety Reporting System could negate the provisions of immunity from punitive action by the FAA. Failure to provide the information may prevent investigation sufficient to eliminate a hazardous air traffic condition.**

APPENDIX D

AIRMAN MANNING LEDGER MAC/DPAFR

272XX FORCE

GRADE SKILL LEVEL	CURRENT AUTH	CURRENT ASGN	%	PROJECTED FY 3/79 AUTH	PROJECTED FY 3/79 ASGN	%
27210						
E3 - E1	0	0	-	0	4	
E4	0	21	-	0	17	-
E5	0	3	-	0	2	-
E6	0	1	-	0	1	-
E7	0	1	-	0	1	-
TOTALS	0	30	-	0	25	-
27230						
E3 - E-1	695	535	77%	695	797	114%
E4	0	246	-	0	247	-
E5	0	83	-	0	83	-
E6	0	14	-	0	14	-
E7	0	6	-	0	6	-
TOTALS	695	884	127%	695	1147	165%
27250						
E3	72	600	833%	64	602	941%
E4	1374	1630	119%	1416	1333	94%
E5	1088	456	42%	1079	447	41%
E6	0	7	-	0	9	-
E7	0	2	-	0	2	-
E8	0	0	-	0	0	-
TOTALS	2534	2695	106%	2559	2393	94%
27270						
E5	136	746	549%	137	710	518%
E6	1145	708	62%	1138	691	61%
E7	607	425	70%	605	415	69%
E8	0	4	-	0	4	-
TOTALS	1938	1883	97%	1880	1820	97%

GRADE SKILL LEVEL	CURRENT AUTH	ASGN	%	PROJECTED FY 3/79 AUTH	ASGN	%
27290						
E7	34	162	476%	35	136	389%
E8	201	158	79%	203	141	69%
E9	96	87	91%	94	78	83%
TOTALS	331	407	123%	332	355	107%
TOTALS	5448	5899	107%	5466	5740	105%

SOURCE: AIRMAN MANNING LEDGER (PART II)

AS OF: 31 July 78

SOURCE: MAC/DPAFR

APPENDIX E

27290/70 LOSSES 1972-1978 MAC/DPAFR

We lose an average of 49 9-levels and 191 7-levels per year. Based on our current 9-level authorizations (330), we turn over the force in just over 6 years, 9.8 years for the 7-level force. Specific losses per year are:

	27290	27270
FY 78 (2 qtrs)	43	30
*FY 77	34	169
FY 76	49	207
FY 75	36	192
FY 74	56	178
FY 73	58	184
FY 72	63	215

*Includes the FY transition period (1 Jul 76-30 Sep 76). FY 4/77 data lost.

SOURCE: MAC/DPAFR

APPENDIX F

HATR SUMMARY 1 FEBRUARY 1979

HAZARDOUS AIR TRAFFIC REPORT (HATR)

Quarterly Summary

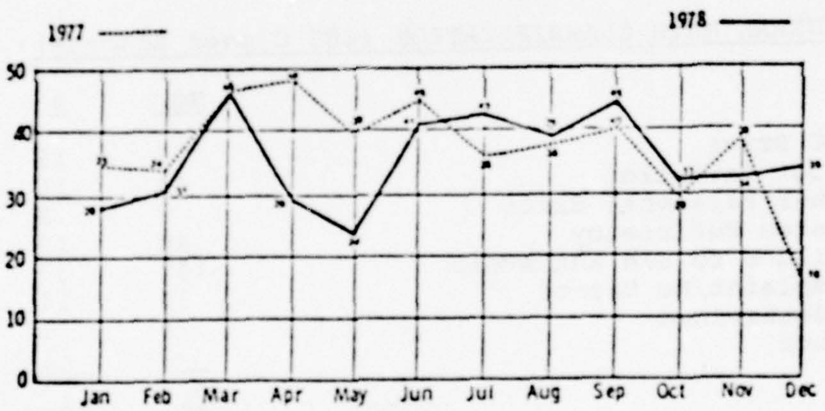
1 FEBRUARY 1979

A. HATRs RECEIVED:

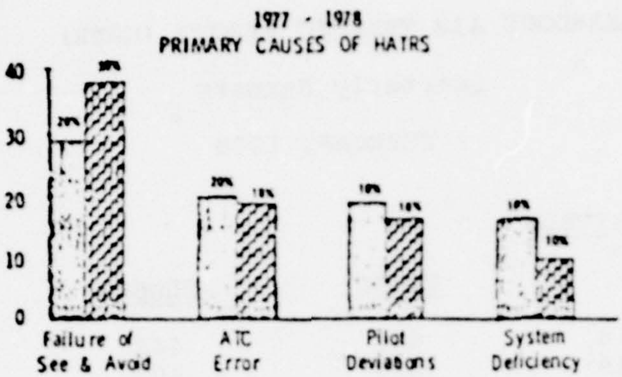
	TOTAL	CLOSED	OPEN
1977 Totals	442	442	0
1978 Totals	428	403	25
Jan 1979	23	15	8

B. DATA ANALYSIS. The analysis in this summary refers to 1978 calendar year CLOSED reports.

1977/1978 HATR COMPARISON



2. Two significant deviations were noted from the 1977 figures: Reported system deficiencies decreased almost 38 percent and failure to see and avoid increased by almost 33 percent. Failure of see and avoid is used when both aircraft are operating within prescribed directives but the other aircraft is seen too late to apply right-of-way rules.



3. NMACs and non-NMACs are combined to show the overall classification of 1978 activity. Two HATRs that were caused by equal factors of ATC Error and Pilot Deviation are divided equally between the two categories.

GENERAL HATR CLASSIFICATION (403 Closed Reports):

	No.	%
ATC Error	76	19
Pilot Deviation	64	16
Other Personnel Error	9	2
System Deficiency	40	10
Failure to See and Avoid	152	37
Complaint/No Hazard	59	14
Undetermined	1	1
Other	2	1
Total	403	100%

4. One hundred fifty-nine of the 403 closed HATRs did not involve a near midair collision.

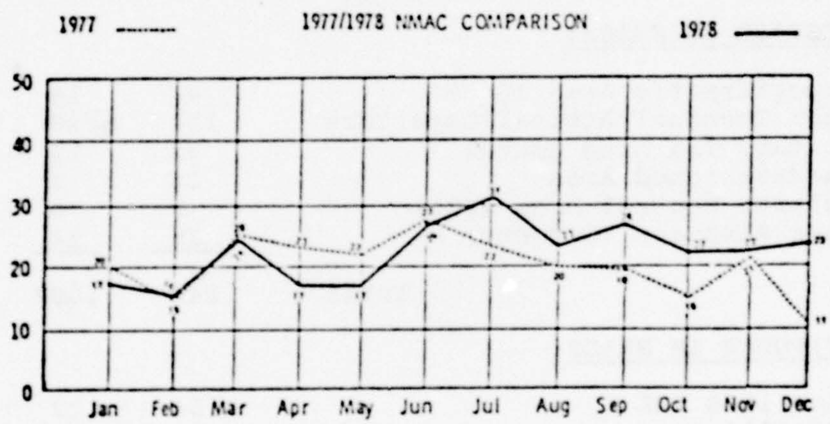
CLASSIFICATION OF NON-NMACs:

ATC Error:

USAF	-	30			
FAA	-	8			
Host Nation	-	8			
Other DOD	-	2	=	48	30

		NO.	%
Pilot Deviation:			
USAF - 7			
Non-USAF - 11	=	18	11
Other Personnel Error		9	6
System Deficiency		22	14
Complaint/No Hazard		59	37
Undetermined		1	1
Other		2	1
	Total	159	100%

5. Out of 403 closed reports, 244 were classified as NMACs.



CLASSIFICATION OF NMACS (244 Closed Reports):

Failure to See and Avoid		152	62
ATC Error:			
USAF - 15			
FAA - 6			
Host Nation - 6			
Other DOD - 0	=	27	11
Pilot Deviation:			
USAF - 6			
Non-USAF - 39	=	45	19

		NO.	%
ATC Error/Pilot		2	1
System Deficiency		18	7
	Total	244	100%

TOTAL NMACs with:

General Aviation		193	79
Other USAF		21	8
Foreign Military		10	4
Air Carriers		6	3
Other DOD		6	3
Unknown		5	2
No USAF Aircraft Involved		3	1
	Total	244	100%

AIRSPACE IN NMACs:

AirportTraffic Area (5 SM)		44	18
Other Terminal Arrival/Departure		118	48
Military Training Routes		33	14
MOA/Restricted Area		14	6
Positive Control Area (PCA)		0	0
Other Airspace (Enroute)		35	14
	Total	244	100%

ALTITUDES IN NMACS:

Below 1500 AGL		54	22
1500-3000 AGL		93	38
3000-7500		68	27
7500-12,500		15	6
12,500-18,000		6	3
Above FL180		8*	4
	Total	244	100%

*Only one occurred inside the CONUS

USAF AIRCRAFT TYPES INVOLVED IN NMACs:

TYPE	77	78	TYPE	77	78
F-4	64	65	C-9	6	3
T-38	26	26	F-100	5	1
T-37	25	20	F-15	4	2
B-52	18	29	C-5	4	1

See-and-avoid is a visual procedure wherein all pilots of aircraft flying in VMC conditions, regardless of type of flight plan, are charged with the responsibility to observe other aircraft and to maneuver their aircraft as required to avoid them. Right-of-way rules contained in FAR, Part 91, should be used when executing the avoidance maneuvers.

2. Pilot deviation ranked second among the major causes of NMACs during 1978. Non-USAF pilots involved in 37 of the 43 incidents reported were found to have operated within congested, controlled airspace without contacting the air traffic control agency. A general lack of pilot vigilance and violations of Federal Aviation Regulations placed these flyers in dangerous situations.

Base flying safety officers and air traffic control managers are strongly encouraged to establish and maintain comprehensive pilot information and education programs with civil aviators, fixed-base operators, and airport managers located around military bases. Pilots should also be encouraged to visit air traffic control facilities to familiarize themselves with the ATC system, its functions, responsibilities, and benefits.

3. A third major cause of NMACs was air traffic control error. This factor contributed 11 percent of the total NMACs reported.

Generally speaking, the most commonly reported controller errors included: Lack of inter/intrafacility coordination; radar misidentification; and inadequate controller instruction.

Reports indicated that ATC managers could reduce this factor by establishing improved controller education and training programs; more professional facility management practices; and more frequent review and revision of facility operating instructions.

D. REMARKS:

1. The FAA recently made public their proposed improvements to the National Airspace System. These extensive changes proposed by the FAA will have a significant impact on future USAF operations. Decisions concerning exclusion or inclusion of air bases into Terminal Control Areas, Terminal Radar Service Areas, and other midair collision prevention plans are yet to be made. It is imperative that we stay informed and actively participate in discussions

TYPE	77	78	TYPE	77	78
C-130	16	15	A-37	4	2
C-135	15	17	OV-10	3	4
C-141	14	21	T-33	3	2
F-111	12	8	T-43	2	2
F-105	9	4	F-5	2	0
T-39	9	12	F-101	2	0
A-4	1	1	T-41	1	0
F-104	0	3	E-3	1	0
F-106	0	3	C-7	1	0
C-123	0	2	UH-1	1	6
C-6	0	1	H-53	1	0
O-2	7	4	H-3	0	2
A-7	7	2			

C. MAJOR CAUSE FACTORS:

1. Failure of pilots to see-and-avoid each other remains the leading cause of all reported NMACs. Between Jan 77 and Dec 78, 280 NMACs, or 54 percent of all NMACs reported, were caused by this one environmental factor. The majority of these incidents involved an uncontrolled aircraft, within 10 miles of an airport, and between 1500-5000 feet AGL. General aviation pilots were a factor in 77 percent of these near collisions.

Many of these situations could have been avoided if more general aviation pilots had taken advantage of the various VFR traffic advisory services available to aircraft flying in controlled airspace.

There isn't any substitute for alertness while in the vicinity of an airport. As a standard operating procedure, all inbound traffic should continuously monitor the appropriate control/advisory frequency from 15 miles to landing. Aircraft transiting the area should contact the controlling ATC facility.

All pilots should be encouraged to use the radar traffic information service provided by radar air traffic control facilities. Pilots using this service are normally advised of any radar targets observed in proximity to their aircraft or intended route of flight that warrants their attention. This service, however, is NOT intended to relieve the pilot of the responsibility to see and avoid other aircraft.

at all levels with the FAA. Base airspace and air traffic managers are strongly encouraged to discuss these proposals and their impact on local operations with FAA counterparts. We are prepared to render as much assistance as possible.

2. Overall HATR submission was down approximately 3 percent in 1978. However, NMACs accounted for over 60 percent of the HATRs validated in 1978.

3. The revised AFR 127-3 finally hit the field in November 1978. We have had some questions concerning the new reg:

- The word "TO" was inadvertently omitted from the address element for the preliminary message on attachment 1.

- CONUS safety officers that receive HATRS concerning incidents at overseas locations should follow paragraphs 7c and 7d of AFR 127-3 rather than send the preliminary of final messages themselves. The preliminary or final message should be initiated by the safety office given that responsibility by the oversea MAJCOM director of safety.

- Be sure to send an info copy of HATR messages to the General Aviation District Office (GADO) or the Air Carrier District Office (ACDO) if the HATR involves a NMAC with a general aviation or air carrier aircraft. Call your local FSS, the AF Rep, or us for the proper addresses.

- FAA and other DOD agencies should only be addressed when the conditions listed in the message format fit the incident. If the incident only involves USAF aircraft and/or USAF air traffic services, these other agencies need not be sent copies.

4. We have a new air traffic control analyst here at AFISC. MSgt Marshall Holman replaced SMSgt Bob Bentley in January and is up to his ears in HATRs. He has a tough act to follow. Bob Bentley was with the HATR Program from its inception and did a truly outstanding job. His dedication, expert knowledge of the ATC system, and the incisive manner contributed to significant improvement in the HATR Program. Give MSgt Holman or Maj Yadouga a call if you have any questions on the HATR Program (AUTOVON 876-2244/2581).

APPENDIX G

DATA FORMAT FOR HATR FILE

MASTER SECTION DATA FIELD

CODE PRINT TABLE (A CARD)

Card Column	Position	Description	Characters Utilized
1		Input Action	E = Enter C = Change b̸ = Delete
2-7	1-6	Date	Calendar Year, Month and Day
8	7	Record No.	1 thru 9
9		Field Identification	A
10	8	Report Type	A = Accident B = Minor Accident H = HATR I = Incident N = HATR Not Involving AFCS
11-30	9-28	Location	
31	29	Comm Area	A = 1931CG S = SCA E = ECA T = TCA N = NCA X = SACCA P = PCA
32	30	MAJCOM	A = ALAC M = AFRES C = ADC Q = MAC D = USAFE R = PACAF F = AFLC S = SAC H = AFSC T = TAC J = ATC Y = AFCS K = AU b̸ = ANG L = SOAC
33	31	Facility	A = VORTAC N = TACAN B = GCI P = PAR C = Center R = RAPCON G = GCA T = Tower J = JLS V = VOR M = MRAPCON Blank = Other

Card Column	Position	Description	Characters Utilized
34	32	Primary Cause	C = Controller Error
35	33	Secondary Cause	P = Pilot Error
36	34	Tertiary Cause	S = Supervisory Error M = Material Factor E = Environmental Factor X = Maintenance Factor A = ATC System D = Design Factor O = Other Blank
37	35	Classification	A = System Error and Near Midair Collision B = System Deviation and Near Midair Collision C = Pilot Deviation and Near Midair Collision D = System Deviation N = Near Midair Collision P = Pilot Deviation Q = System Deviation and Pilot Deviation R = System Error and Pilot Deviation S = System Error T = Pilot Complaint Blank = Not Classified
38-50	36-48	Aircraft Type	
51-52	49-50	Phase of Flight, Acft #1	A = Terminal Arrival E = Enroute F = Final Approach (Visual)
53-54	41-52	Phase of Flight, Acft #2	T = Taxi L = Landing AA = ASR Approach IA = ILS Approach LA = Low Approach RA = PAR Approach TA = TACAN Approach

Card Column	Position	Description	Characters Utilized
			VA = VOR Approach TD = Terminal Departure TO = Takeoff TP = Traffic Pattern HP = Holding Pattern BS = Uncontrolled VRF Aircraft CV = Controlled VFR Aircraft AR = Airborn Radar Approach LT = Low Altitude Training Route OB = Olive Branch Route MO = MOA Operation ST = Stage Service OV = IFR Overflight NA = Not Applicable Blank = Other Phases of Flight
55-58	53-56	Local Time	0 thru 9 or Blank
59	57	Weather	W = Day VFR X = Day IFR Y = Night VFR Z = Night IFR Blank = Not Available
60	58	Traffic Conditions	L = Light M = Moderate H = Heavy N = Not Available Blank = Not Reported
61	59	Crew Chief on Duty	Y = Yes N = No Blank = Not Reported
62	60	Prior Emergency Declared	Y = Yes N = No Blank = Not Reported
63	61	Primary Category	A = Procedural B = Coordination C = Judgement

Card Column	Position	Description	Characters Utilized
64	62	Secondary Category	D = Supervisory E = Communication F = Equipment G = Technique H = TERPS Bland = Uncategorized
65	63	Error Type	A = Airspace Violation B = Final Approach C = Traffic Pattern D = Altitude Verification E = Error Identification F = Radar Separation G = Runway Separation H = Wake Turbulence I = Procedural Separation J = Barrier K = Wheels Check L = Radar Handoff M = Transfer of Control N = Safety Limits O = Terrain Clearance P = Advisories Q = Radar Vectors R = Radar Identification S = Radar Approach T = No-Gyro Approach U = Nordo V = Emergency W = Clearance X = Light Signals Y = Abort Z = Crash 1 = Altimeter 2 = Control Instructions 3 = Sectorization 4 = Manning 5 = Saturation 6 = Call Sign 7 = Minimum Descent Altitude 8 = Departure Release 9 = Depiction Blank = Not Applicable

Card Column	Position	Description	Characters Utilized
67-68	65-66	Facilities	A = RAPCON B = MRAPCON C = RATCC D = TRACON(FAA) E = GCA F = Tower (VFR) G = Tower (IFR) H = Tower (Mobile I = Tower (FAA) J = ARTCC (FAA) Blank = Not Applicable
69-70	67-68	Positions	A = Approach B = Departure C = Arrival D = Final E = Coordinator F = Local G = Ground H = Flight Data I = Crew Chief J = Senior Controller K = Watch Supervisor L = Assistant M = Enroute Blank = Not Applicable
71-72	69-70	Equipment	A = TACAN B = ILS C = VOR D = VORTAC E = NOB F = ASR G = PAR H = IFF/SIF I = Video Map J = Radio K = Landline L = Light Gun M = BRITE II Blank = Not Applicable
73-74	71-72	Equipment Status	A = Unusable B = Weak C = Saturated D = Garbled E = Interference

Card Column	Position	Description	Characters Utilized
			F = Unreadable G = Not Available H = Alignment I = Cross Talk J = DME Unlocks K = Coverage L = Power Blank = Not Applicable
75-78	73-76	Unused	
79	77	Report Status	C = Closed 0 = Open
80	78	Field Identification	A

SELECTED BIBLIOGRAPHY

REFERENCES CITED

1. Cobb, Bart B., M.S. "The Relationships Between Chronological Age, Length of Experience, and Job Performance Ratings of Air Traffic Control Specialists." Unpublished research report No. AM 67-1, Office of Aviation Medicine, Department of Transportation, Federal Aviation Administration, Oklahoma City OK, 1967.

2. Corrdino, Arnold, Personnel and Procedure Branch (AAT 14) Headquarters Federal Aviation Agency, Washington, D.C. Telephone interview. 19 January 1979.

3. Hauty, George T., Ph.D., David K. Trites, Ph.D., and William J. Berkley. "Biomedical Survey of ATC Facilities." Unpublished research report No. AM 65-6, Office of Aviation Medicine, Department of Transportation, Federal Aviation Administration, Oklahoma City OK, 1965.

4. Herbert, Francis E., Chief Warrant Officer, USAF retired, Director, USAF Air Traffic Control Learning Resource Center, 3395 Technical Training Group/TTKO, Keesler AFB MS. Telephone interview. 17 January 1979.

5. Hodges, Chief Master Sergeant Dennis L., USAF, Air Traffic Control Liaison Officer, FAA Aeronautical Center, Oklahoma City OK. Telephone interview. 15 January 1979, 17 January 1979.

6. Hopkin, V. D. "Work-Rest Cycles in Air Traffic Control Tasks," in A. J. Benson, ed. Rest and Activity Cycles for the Maintenance and Efficiency of Personnel Concerned with Military Flight Operations, Advisory Group for Aerospace Research and Development, North Atlantic Treaty Organization, Oslo, Norway, May 1970, pp. 10-1 to 10-9. AD 717265.

7. Hulse, Major Henry A., Terminal Control and Landing System Branch, HQ USCS, Scott AFB IL. Telephone interview. 13 December 1978, 8 January 1979.

8. Lewis, Mary, Dr., FAA Psychological Branch, FAA Aeronautical Center, Oklahoma City OK. Telephone interview. 31 January 1979.

9. Martinson, Lieutenant Colonel David J., Chief Air Traffic Control Support Branch, HQ AFCS/FCC, Scott AFB IL. Telephone Interview. 13 December 1978, 2 January 1979.

10. McNichols, Charles W. Course Notes for Applied Multi-variant Data Analysis, School of Engineering, Air Force Institute of Technology, Wright-Patterson AFB OH, 1978.

11. Missman, Major Richard A., Course Supervisor, 1611, Air Traffic Control Staff Officers Course, 3395 Technical Training Group, TTKO, Keesler AFB MS. Telephone interview. 10 January 1979.

12. Nie, Norman and others. Statistical Package for the Social Sciences, 2nd ed., New York: McGraw-Hill, Inc., 1975.

13. Perry, Captain Richard E., Air Traffic Control Support Branch, HQ AFCS/FFCS, Scott AFB IL. Telephone Interview. 13, 14 December 1978, 9, 11 January 1979.

14. Shedd, Chief Master Sergeant Perry E., NCOIC, Air Traffic Control Support Branch, HQ AFCS/FFCS, Scott AFB IL: Telephone interview. 16 January 1979.

15. Smith, Lieutenant Colonel Marvin L., Chief, Air Traffic Control Training Branch, 3395 Technical Training Group/TTKO, Keesler AFB MS. Telephone interview. 19 January 1979.

16. Vandergriff, Chief Master Sergeant Jack A., Course Superientendent, Air Traffic Control Training Branch, 3395 Technical Training Group/TTKO, Keesler AFB MS. Telephone interview. 17 January 1979.

17. Youdouga, Major Joseph A., Chief, Air Traffic Control Procedures Branch USAF Safety Center, Norton AFB CA. Telephone interview. 13 December 1978, 17 January 1979.

18. Zetzmann, Hans J., Dr. "'Workload' and 'Performance Limiting Factors' of Air Traffic Control Radar Operations," in A. J. Benson, ed. Rest and Activity Cycles for the Maintenance and Efficiency of Personnel Concerned with Military Flight Operations, Advisory Group for Aerospace Research and Development, North Atlantic Treaty Organization, Oslo, Norway, May 1970, pp. 9-1 to 9-11. AD 717265.